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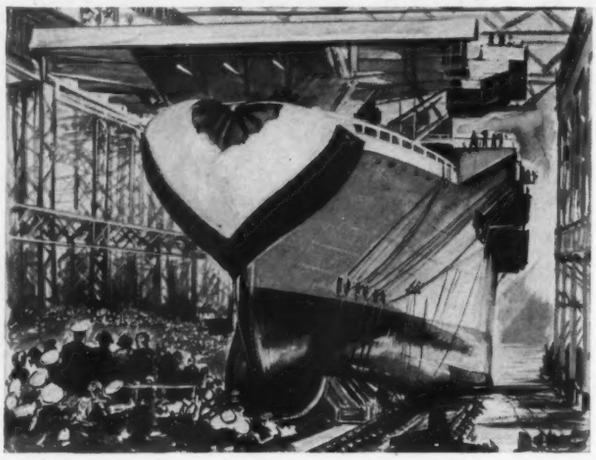

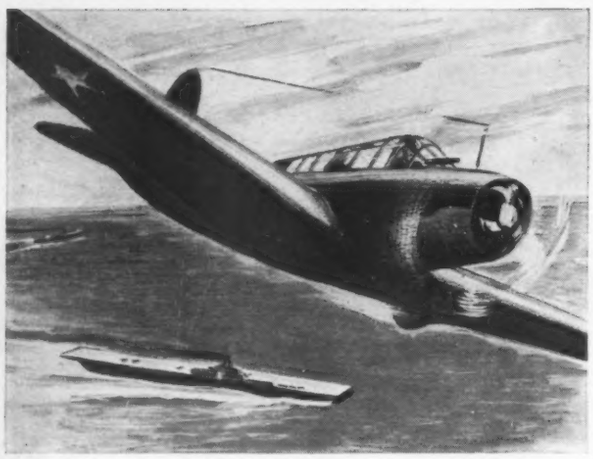

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PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

MAY, 1943
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GRADY TRIPLETT
Editor

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SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

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THE LOOK BOX

THIS estimate of yield and cost of butadiene from grain alcohol was given to the National Farm Chermugic Conference in Chicago, March 25 by Charles L. Gabriel, vice president of Publicker Commercial Alcohol Company:

Butadiene Economics

"Assuming a normal rubber consumption in this country of 600,000 tons and a yield of 2.25 pounds of butadiene per gallon of alcohol, 400,000,000 gallons of alcohol would be required to produce the needed 450,000 tons of butadiene. As a bushel of grain yields about 2.25 gallons of alcohol, about 160,000,000 bushels would be needed as raw materials for its production. . . . With alcohol (from grain) selling at 50 cents per gallon and today costing almost as much to make, butadiene produced from it will undoubtedly be more expensive than that produced from petroleum gases. However, in normal times when the cost of alcohol (from molasses) again may be in the neighborhood of 15 cents per gallon, it is believed that butadiene made from alcohol will be competitive with that from petroleum."

IN HIS Monterrey speech, April 20, President Roosevelt gave approval to confiscation of private property, the action by which the Mexican government gained ownership of properties of American corporations at its own estimate of value. He said:

Generous Neighbor

"We know that the day of the exploitation of the resources of the people of one country for the benefit of any group in another country is definitely over."

Reflection on expropriation in Mexico does give credence to the charge that American business men were foolish to venture into contracts under the provisions of the Mexican constitution of 1917. Even the Mexican politicians must have doubted the legality of expropriation under the constitution, since a statute of expropriation was passed in 1936. By restricting investigation to three years of doing business in Mexico it was shown that the American corporation made profits of 16 percent, a figure credited for the full time of investment.

What had happened was that another political regime had arisen in Mexico and its labor contingent made demands, with the result that properties were taken at a value determined by labor leaders. The procedure may have been legal. It was not just.

Now the procedure gains the approval of a political regime of the country whose nationals were thus deprived of their property. England, whose prime minister lets the world know that it is not liquidating the British Empire, also lets the world know that the property of its nationals is subject to terms of contract and the claims of English concerns against the Mexican government are still pending.

Business interests of this country have no such support. Instead, the oneness of property rights and human rights is not recognized. It may seem prosaic but the privilege of wearing clothes rests on the right to own clothes.

Approval of expropriation will accomplish one result. It will keep private capital at home. Whether or not this will be beneficial is doubtful. The countries of Central and South America are

rich in resources whose development could become the basis for a lasting good neighbor policy. At the core of that policy should be admission of the sacredness of contracts. That contracts should not allow exploitation is admitted. Once signed, however, both parties should abide by the terms.

American oil concerns were operating in Mexico under provisions of a constitution adopted in 1917. The fact that a statute was passed in 1936 leaves the impression that even the Mexican doubted the legality of expropriation. It is significant that the Mexican Bar Association condemned the law.

Remarks in the old army barracks in Monterrey may have been a grand political gesture but it is a sorry day when a President of the United States charges his nationals with exploitation.

Still in A Muddle

WHEN William M. Jeffers was coming up to the presidency of the Union Pacific system it was not uncommon for him to demand settlement of personal differences by fisticuffs. He was handy with his fists and willing to trade punches.

In Washington as Rubber Director of WPB it is not good practice to hurl the fisticuff challenge but the determined Jeffers still takes on all comers. His latest tiff was with Robert Patterson, Under Secretary of War, something of a mean man in a controversy himself. Patterson expressed the opinion that the stress on rubber-plant construction was retarding the plant capacity for 100-octane-aviation gasoline.

To Jeffers this sounded like an accusation of sabotage and he demanded action, which brought the Truman committee into action. Its hearings are still under way when this issue of PETROLEUM REFINER goes to press.

Previously Jeffers clashed with Elmer Davis, chief of the Office of War Information. Recently Jeffers has made some optimistic statements as to prospects for civilian rubber. It all sounded too rosy for the Davis regime, which countered with a detailed report, which left gloom. According to its findings the rubber situation would get worse before it got better and there were indications that civilians might be compelled to further curtail driving.

Davis defended his report on the ground that the American people should have the facts, which drew this retort from Jeffers:

"If Mr. Elmer Davis has convinced the people they are getting the facts, I am delighted. But I doubt it. Things are definitely on the upward trend so far as rubber is concerned and they won't become worse. If we can get the people to play the game the rubber problem will be behind us in another year."

In the controversy with Patterson, Jeffers also drew another possible antagonist in Harold L. Ickes. The PAW chief sided with his War Department colleague as to what butadiene plants are doing to 100-octane gasoline.

Along with ability, Jeffers battled his way to the top in railroad circles. Whether he can take on all comers in Washington and survive is a doubtful question. However long he remains in Washington, his methods and his attitude have made a favorable impression. Not until he came along to push the Baruch committee program through was there hope of synthetic rubber.

There is hope now because plants are coming into production. Their total capacity is far from what the Baruch committee considered essential but the confidence Jeffers has in capacity operating and building is reassuring. It may be that output will far exceed estimates and thus put the rubber problem behind us in another year.

Too Much Silence

HOWEVER preposterous it seems, the intimations that post-war planning involves deliberate abandonment of synthetic rubber are too numerous and too credible to ignore. Recently William J. Hale, research consultant of Dow Chemical Company, said in a public address that the government already has signed a treaty with South American nations, which calls for abandonment of this product in government-built plants.

There have been other statements to this effect. Thus far no one has denied that this policy prevails in Washington. Its probabilities are the more anticipated because of apparent determination of leaders to supply necessities to the weaker nations after the war.

Tearing down plants is a step further than shipping food to a hungry nation. The two are similar, since providing for the growth of rubber in the Amazon valley could amount to assuring food for its inhabitants.

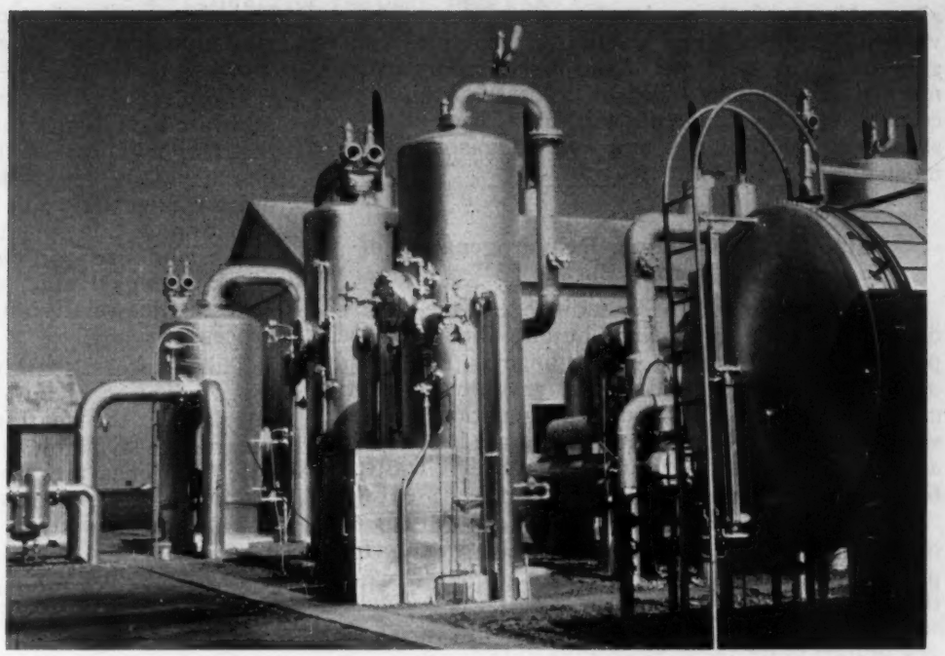
It is difficult to comprehend such a program in the light of what brought the building of plants into necessity. There was no source of rubber in the United States and the foreign supply had been cut off. It would be less dangerous to have the supply on this continent, still a supply in the Amazon valley is still outside the United States.

Good policy demands leaving the supply at home, provided it can establish itself as a going concern.

PAUL M. RAIGORODSKY,
Assistant Director, and

FRANK H. DOTTERWEICH,
Consultant,

Natural Gas and Natural Gasoline Division, Petroleum Administration for War



War Products from Natural Gas and Natural Gasoline

Presented before the twenty-second annual meeting of the Natural Gasoline Association of America, Dallas, April 15, 1943.

THE growth of the petroleum industry during peacetime was accompanied by the production and processing of such great quantities of crude oil that full consideration was not given to the effective utilization of the full range of petroleum raw materials in meeting the increasingly heavy burden of finished product requirements in wartime. This condition, in part, resulted in the waste and devaluation of certain light petroleum derivatives together with a disregard of their use not only as a source of fuel and energy but as a potential source of many chemical and other useful products. Today the rapidly increasing tempo of war activities, accompanied by decreasing crude reserves, shortage of critical materials and transportation difficulties, dictates that all petroleum fractions shall be processed for their most efficient use in the war effort and under these conditions the processing of natural gas and natural gasoline becomes of the greatest importance. In this paper major attention will be given to the actual commercial processes by which these light petroleum fractions may be converted into vital war products.

The increasing importance and value of natural gas and natural gasoline in the war effort may be attributed, in part, to their comparatively large volumes available and the low critical material requirement for their production and processing. By modern methods of fractionation light hydrocarbons may be separated into relatively pure saturated hydrocarbons, valuable in their pure state as blending agents, or when processed by modern catalytic and thermal processes still more valuable as raw material giving remarkable yields of war products. Natural gas is invaluable not only as a source of war products but also in the proper development and production of recently discovered condensate fields due to the complexing phenomena of retrograde condensation.

The future should see increased discoveries of deep petroleum deposits of the "vapor state" type in which the recovered light petroleum fractions will be a greater percentage of the total petroleum products than heretofore, thereby insuring increasing supplies of natural gas and natural gasoline and perpetuating their use in developments which have been accelerated, and in some cases, forced upon the petroleum industry during wartime.

These conditions, relative to the supply and scientific developments, in natural gas and natural gasoline operations have made possible the production of war products, the most important of which are synthetic rubber, carbon black, aviation fuel and explo-

sives. Many of these developments cannot be reviewed herein due to wartime restrictions, but a general report on some of the more important commercial developments and of processes available for commercial development will to a certain degree show that natural gas and natural gasoline play a most important role in the war.

Butadiene by Catalytic Dehydrogenation of Normal Butane

In the production of butadiene by the catalytic dehydrogenation of normal butane the commercial process of the greatest importance is the Houdry one-stage and combined two-stage dehydrogenation catalytic processes. The dehydrogenation occurs in six special catalytic reactors, operated under subatmospheric pressure and at carefully controlled temperatures.

The two-stage process which has been reported[1] is now being constructed by the Standard Oil Company of California, which should go on stream in the near future.

The one-stage process will be used in one of Sun Oil Company's plants which should go into commercial production of 15,000 tons of butadiene per year, early in May.

The one-stage process differs from the original two-stage process by injecting the fresh butane feed with the recycled butane-butene mixture. In this setup there would be two cases operating on butane-butene for 10 minutes or less, two cases regenerating and two cases purging. The reactants flow only upward through the catalyst bed, thereby effecting economies in the size and number of connections to the cases. This method necessitates increased amounts of air and butane or the injection of 746 barrels per day of normal butane to manufacture 15,000 tons of butadiene per calendar year, against 660 barrels originally reported. The most astonishing fact concerning this plant is its construction with practically all second-hand material. New critical material requirements have been limited to small items such as the large vacuum cylinders on compressors, some valves, instruments, and other similar materials. It is very interesting to note the material requirements for this plant when compared with the original estimated requirements. The complete amount of critical material, which it was necessary to purchase under priority for the entire butadiene plant, including dehydrogenation and purification sections and also auxiliary equipment, such as new boilerhouse, electric power services, water services, etc., amounted to 719.8 tons as against the original estimate of 850.6 tons.

Many refinery-conversion projects in the "quickie" program have been canceled, including projects using the Houdry process. It was stated and should be noted that the reason for cancellation of the Houdry units was entirely due to the late date of their construction. A pilot plant with one case of commercial design and size is in continuous operation at Marcus Hook, Pennsylvania, and operating data substantiates claims relative to the efficiency of the Houdry process.

This process continues to be most desirable in the production of butadiene because butane and not butylene is the charging stock. Large quantities of butane are available in many localities while available butylenes are scarce due to great demand for the aviation fuel program.

Butadiene from Ethyl Alcohol

Butadiene can be made from a number of diversified raw materials coming from agricultural and mineral sources and one of the most important raw materials available from both sources is ethyl alcohol.

The many possible processes available to convert ethyl alcohol into butadiene have been carefully reviewed and reported.[2] In this reference, these processes are classified into the following general groups:

1. Direct conversion of ethyl alcohol.
2. The aldol method.
3. Ethylene methods.
4. Acetylene methods.
5. Acetaldehyde condensations and conversion to butadiene.
6. Crotonaldehyde methods.

When natural gas is the raw material in the production of ethyl alcohol, its separation is confined to the following groups: dry gas, ethane-propane mixture, and natural gasoline. The ethane-propane mixture is thermally cracked into ethylene which is reacted first with sulphuric acid, then with water, with ethyl alcohol as the product. This method is being used commercially to produce ethyl alcohol with the sulphuric acid being recovered, concentrated, and recycled.

Under other conditions when natural gas is the raw material the direct conversion, aldol and acetaldehyde condensation methods are of importance, Figure No. 2.

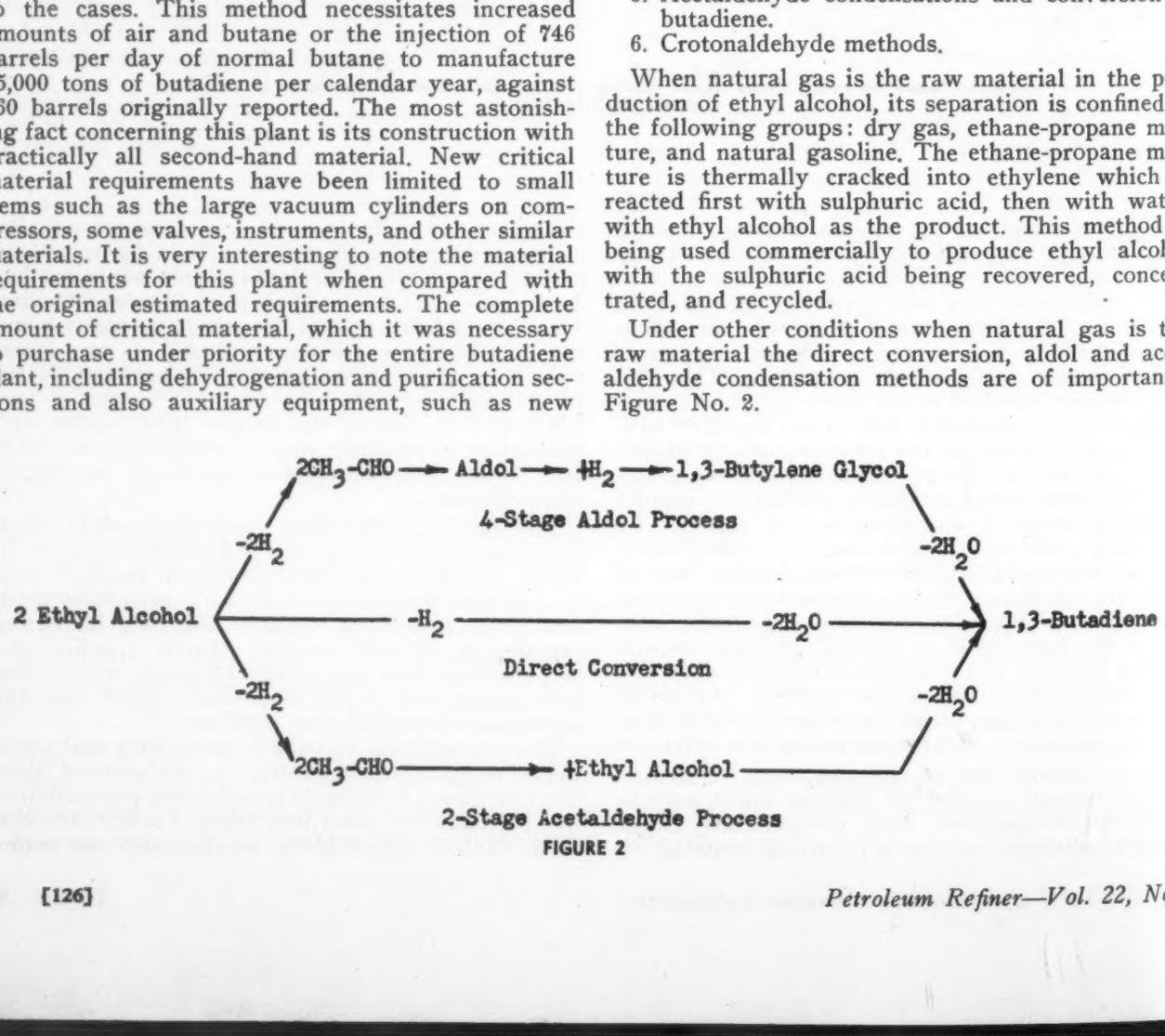


FIGURE 2

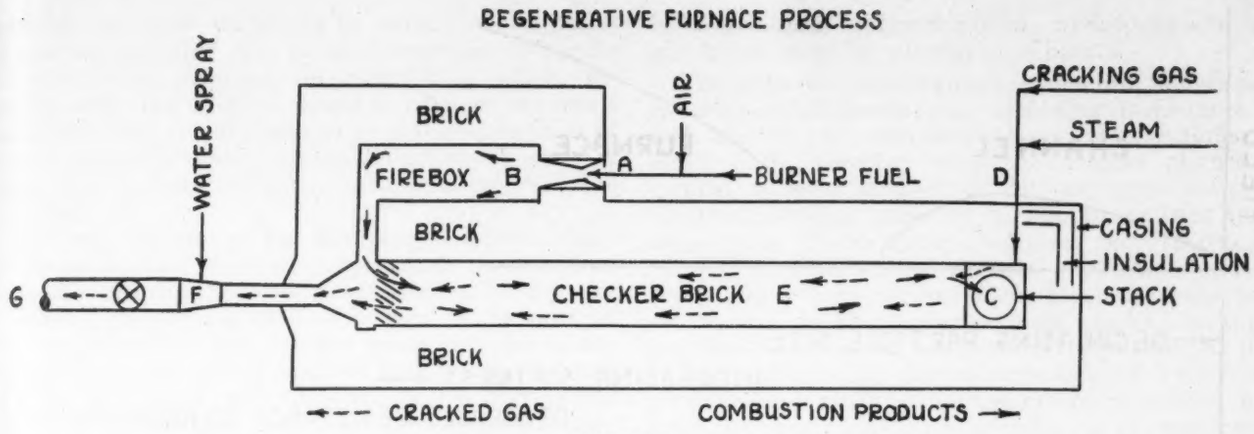


FIGURE 3

It appears that at the present time alcohol manufactured from natural gas is not being used to produce butadiene. However, a plant is now in commercial production of butadiene from alcohol with most encouraging yields using the two-stage method of conversion. It is interesting to note that in this plant the original design called for the production of alcohol from ethylene as previously indicated.

Regenerative Furnace Method

Petroleum Chemicals, Incorporated, has designed and built at its Baltimore plant a semi-commercial unit for the cracking of hydrocarbons by regenerative heating and for the separation and purification of the olefines produced. This type furnace was partially developed by Tennessee Eastman Corporation under the supervision of Dr. R. L. Hasche[8] in connection with the production of acetylene by thermal cracking and has been adapted to the production of butadiene utilizing heavy naphtha as charging stock, and it is reported that a yield of 5.2 weight percent of butadiene was obtained, Figure No. 3.

During the firing cycle, fuel gas and air are fed to the pressure burner. Combustion is complete in the fire box, the air supply may be closely regulated to give practically no excess air and the products leave through the stack, steam purges at the end of the cracking, and firing cycles prevent contamination of the product. The vaporized feed at about 500° F. is mixed with low-pressure steam and fed to the furnace. Cracking is effected over the carborundum checker work, previously brought to heat in the firing period, and the cracked products on leaving the furnace are cooled by means of direct water sprays to about 130° F., then conducted to concentration and purification apparatus.

The development of the modern regenerative furnace is not only of importance as a possible method of butadiene production from condensate, but offers a splendid method by which by-product ethane-propane mixtures may be cracked to ethylene, propylene and benzene mixtures. These raw materials are of importance in the manufacture of aviation fuel and this subject will be discussed herein.

It is reported that the operation of the regenerative furnace is superior to the commercial method of tubular cracking when overall yields of desirable unsaturated hydrocarbons are of importance.

Carbon Black

The development of synthetic rubber and its increased production is being accompanied by increased production of new types of carbon black essential in compounding procedures. In the past, natural gas has been the raw material in the production of channel blacks required in compounding natural rubber, and this raw material continues to supply the newer types of carbon black, i.e., furnace and thermatomic blacks which are required in compounding synthetic rubber.

The necessity of increased production of furnace and thermatomic blacks may be explained by a discussion of the properties of carbon black when compounded with natural and synthetic rubber, Chart 1.

With crude rubber available, channel blacks were satisfactory for blending purposes in automobile tire manufacture. Carbon with the smallest particle size and with a maximum of heat generation and abrasive resistance would be the hardest. Increased particle size is accompanied by decreased heat generation and abrasive resistance. In addition it should be noted that yields of carbon black are a minimum with the fine particle size, increasing to a maximum with increasing particle size up to a certain point and then decreasing with the maximum particle size in channel operations. From these grades of channel black a suitable black would be obtained to give maximum wear resistance to various size tires in which the geometric shape had pronounced effect upon heat-transfer conditions. This suggests that the larger, softer, particle-size black with decreased abrasive resistance was necessary in large truck and bus tires to give an overall maximum wearing property while the hard, smaller-size black was preferable in the manufacture of normal-size automobile tires.

With the advent of synthetic rubber, changes in carbon-black production and blending were imminent. This, in part, was brought about because synthetic rubber has a low tensile strength, necessitating the use of carbon black in greater amounts and in certain portions of the tire and tube where heretofore it was not used.

In addition, synthetic rubber does not bounce to the same extent as natural rubber, resulting in a greater portion of energy being converted into heat. These conditions dictate that heat generation be kept to a minimum by increasing particle size and decreasing hardness and abrasive resistance to impart an overall maximum wearing quality to synthetic-rubber products. To obtain these softer blacks, processes other than the channel must be employed and today large quantities of this material are being

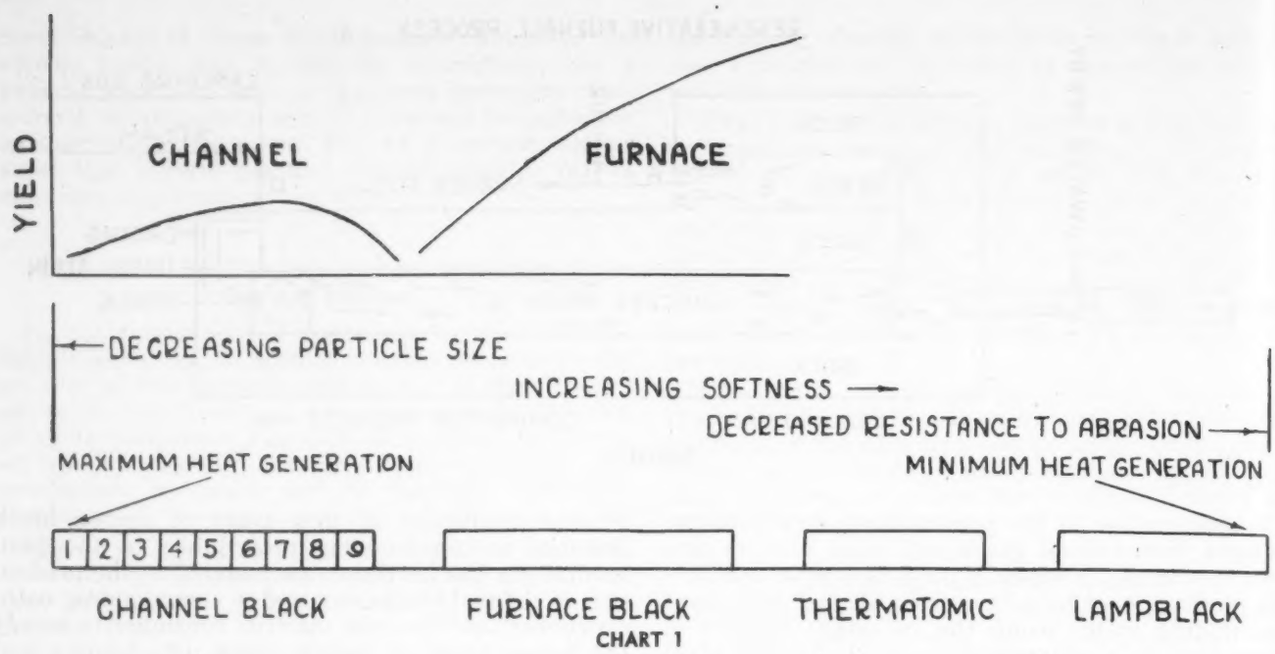


CHART 1

manufactured by the furnace and thermatomic methods.

In the furnace process, natural gas is burned under carefully controlled conditions with definite proportions of air to give the quality of black desired. The products are piped from the furnace to cyclone and electrical precipitation apparatus where the black is recovered and prepared for shipment. In general the efficiency of this process increases with increased particle size with yields of from 3 to 20 pounds per 1000 cubic feet of gas against a yield of from 1 to 5 pounds in the channel process, Figure No. 4.

Soft blacks may also be manufactured by thermatomic cracking operations. In this method carbonaceous vapors or gasses are heated to a decomposition temperature by external heating with or without air in the forming chamber.

These blacks with their great range in properties have allowed for the development of a suitable blending material for our relatively new types of synthetic rubber, not only imparting comparative abrasive and wear resistance when compared with natural rubber but marked increased resistance to aging and tear resistance together with chemical inertness.

Aviation Gasoline From Derivatives

Aviation gasoline continues to maintain the greatest interest in petroleum operations and too much emphasis cannot be placed upon the many available

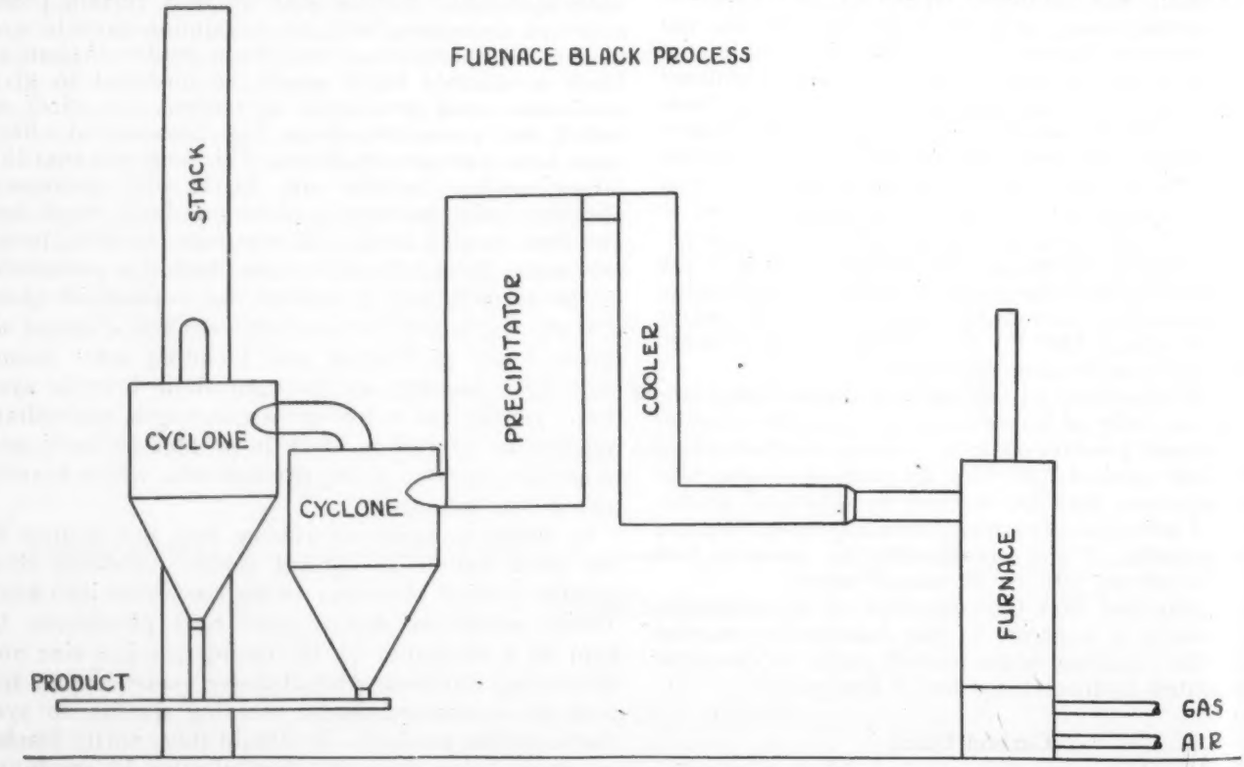


FIGURE 4

methods and raw materials by which our supplies of aviation gasoline may be supplemented. With the ever-increasing demand for aviation gasoline, together with the critical shortage of new materials and decreasing crude reserves, available quantities of natural gasoline and condensate become of extreme value when their synthesis into aviation fuels is investigated.

The participation of the natural-gasoline industry in the production of aviation fuel needs no introduction; the economics and practicability of the use of natural gasoline is verified in that at the present time 30,000 barrels per day are going into the manufacture of 87-, 91- and 100-octane fuel, and by the end of 1943 this figure will approach 70,000 barrels per day. In addition it is estimated that approximately 175,000 barrels per day of natural gasoline and condensate are going into motor fuel, and a considerable portion of this may be made available for aviation-fuel production. The imminent shortage of petroleum products must not be construed as being accompanied by a shortage of natural gasoline and condensate. On the contrary, sufficient raw materials are available and this amount may be increased by producing proven condensate reserves. New equipment will be required to produce and stabilize the desired amounts of natural gasoline but the overall new material requirement is very small when compared to that amount required to drill new wells, transport and prepare a similar quantity and type of hydrocarbon raw material from petroleum.

In processing natural gasoline and condensate, modern methods of stabilization, isomerization, dehydrogenation, polymerization, hydrogenation and alkylation may be employed, Chart 2.

The value of natural-gasoline blending agents now in commercial production, including isopentane, is well known but with more exact specifications for super fuels, together with the current picture of critical material and crude oil, any new blending agent possessing superior blending qualities is of importance. Under these conditions the great possibilities of catalytic and thermal conversion of relatively pure light hydrocarbon fractions into base stocks and the processing of these stocks into super aviation blends must not be underestimated. As previously stated, the thermal cracking of by-product propane and ethane, in regenerative furnaces, into ethylene, propylene and benzene is of importanc. Ethylene with isobutane, natural or isomerized from normal butane, has in the past produced neohexane, a super blend. The future may see the same raw materials, ethylene and isobutane, producing super blends of still greater value. Propylene and benzene are now being alkylated to produce cumene, a super-rich-mixture blend, and in addition cumene may be thermally cracked to give a 50 percent yield of styrene for synthetic-rubber production.

Explosives

The use of natural gas as a raw material in highly efficient proceses requiring a minimum of new critical construction materials has made possible immense production of explosives. By modern methods of oxidation and cracking, natural gas may be con-

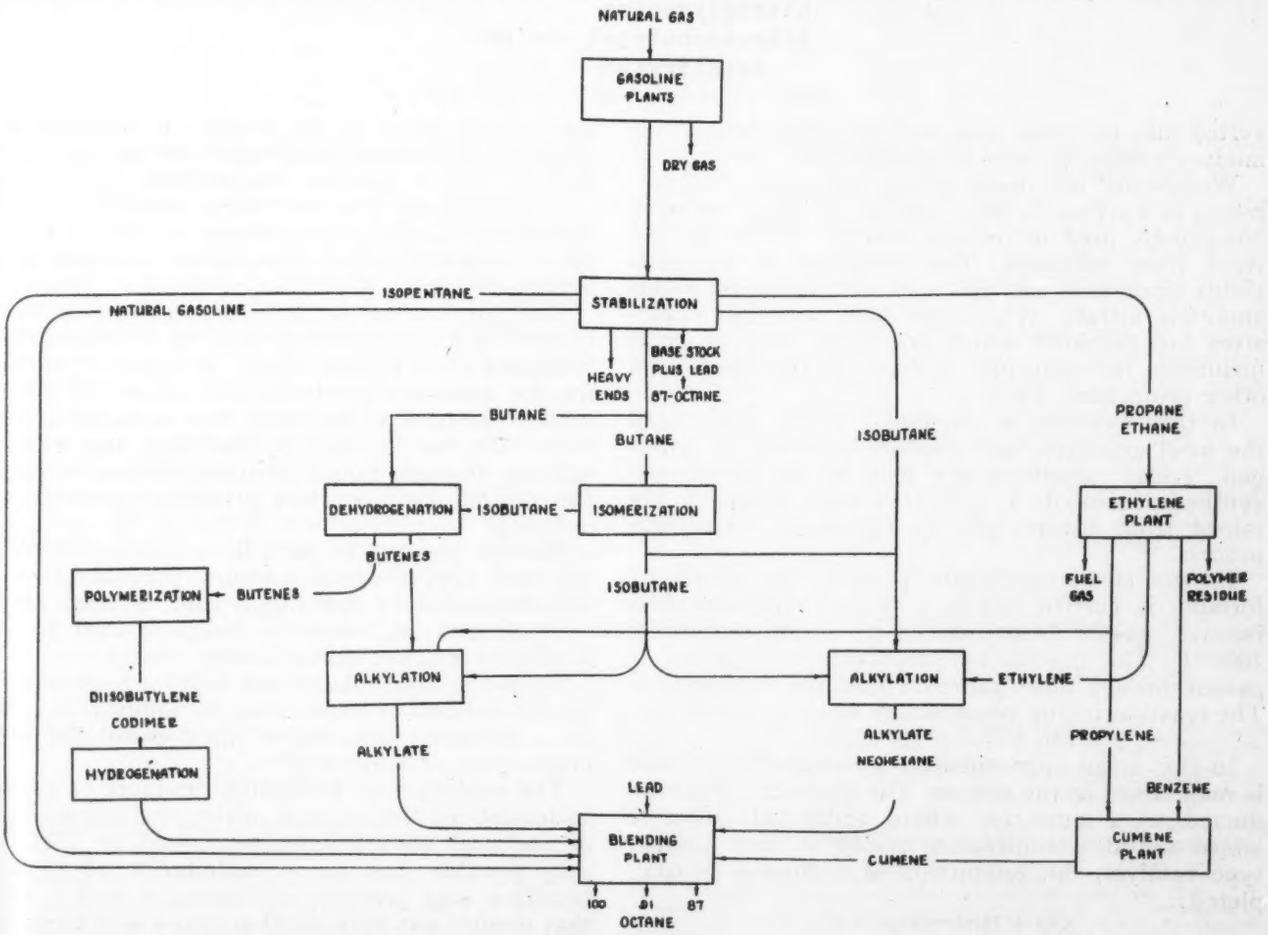
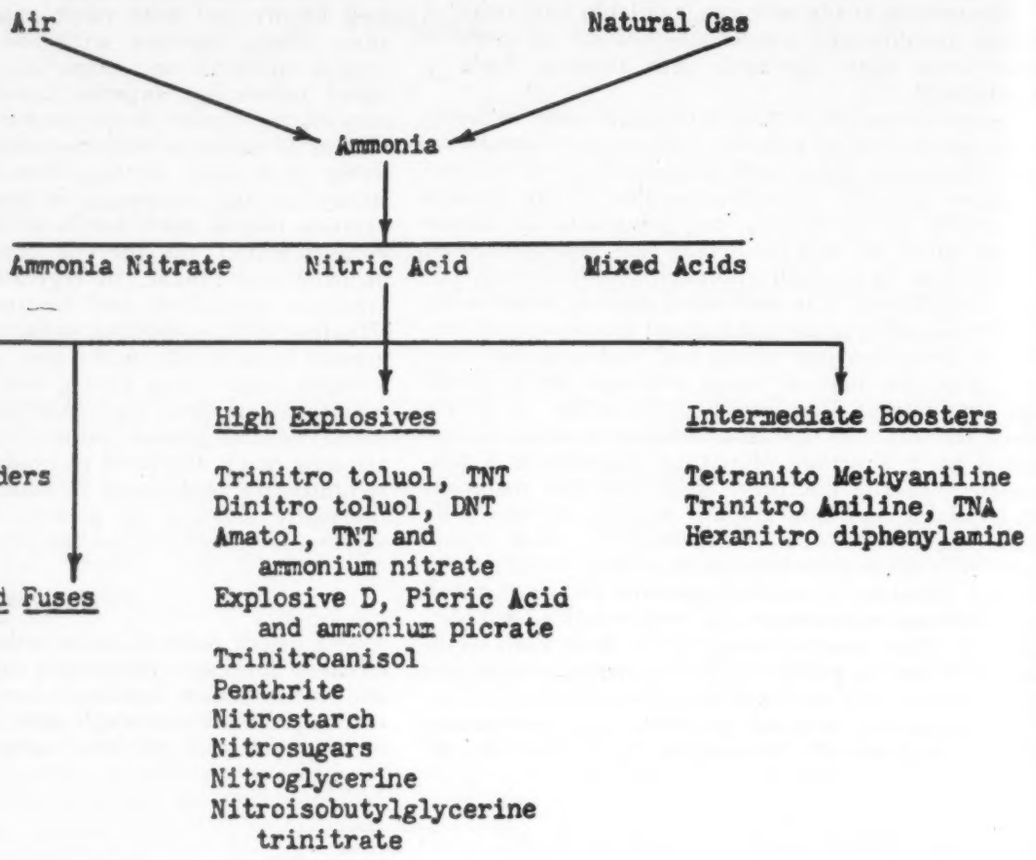


CHART 2

Flow sheet illustrating processes related to production of aviation gasoline from natural gasoline derivatives.

Table I. NITRO COMPOUNDS



verted into the basic raw materials from which our modern explosives may be synthesized.

Woodward[4] has discussed the significance of ammonia in wartime in detail and lists various nitrogen compounds used in modern warfare which are derived from ammonia. The oxidation of ammonia yields nitric acid and this acid with ammonia yields ammonia nitrate. With these base materials explosives are prepared which are being used in great quantities for charging airplane bombs, shells and other projectiles, Table 1.

In the snythesis of ammonia, of the gases used the most expensive and difficult to obtain is hydrogen. Today approximately half of the emergency synthetic ammonia is prepared with hydrogen obtained from natural gas by the steam conversion process.

In the steam-conversion process the initial reforming is carried out in a radiant-type downflow furnace, gas-fired, maintained at a temperature of 1600° F. The gas to be processed, plus steam, is passed through tubes packed with catalysts, Figure 5. The reaction taking place in this stage is as follows:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

In this stage approximately atmospheric pressure is maintained in the system. The gases are then conducted to a converter where additional steam is added and at a temperature of 850° F. with another type catalyst, the production of hydrogen is completed:

$$CO + H_2O \rightarrow CO_2 + H_2$$

The gas is then cooled and conducted to the gas holder before being compressed. The analysis of this gas, at this point in the system, is reported to be roughly 78 percent hydrogen, 20 percent carbon dioxide, and 2 percent unconverted hydrocarbons and other gases. It is extremely important that the natural gas used in this process be free of any sulphur compounds, such compounds resulting in catalyst poisoning.

The gas can be scrubbed of its carbon dioxide content and the scrubbing medium revivified should hydrogen of 97 percent purity be required. However for the ammonia synthesis one volume of nitrogen with 3 volumes of hydrogen are required and this ratio may be obtained by bubbling the hydrogen mixture through liquid nitrogen, thereby supplying the desired nitrogen and attaining purification in one step.

Natural gas may be partially oxidized with air and the hydrogen-nitrogen mixture purified. However this method does not supply the required amount of hydrogen and must be supplemented by pure hydrogen obtained from another source.

Synthetic ammonia is not only of importance in the production of explosives, in addition it is used as a fertilizer base, rubber accelerator and in the preparation of nitroparaffins.

The exploitation of nitrated products of aromatic hydrocarbons has resulted in the production of some of our most powerful explosives such as TNT. It is very possible that future exploitation of the nitroparaffins may produce explosives of such a nature that natural gas may develop into a still more valuable source of explosives than at present.

Benzene and toluene are valuable war products

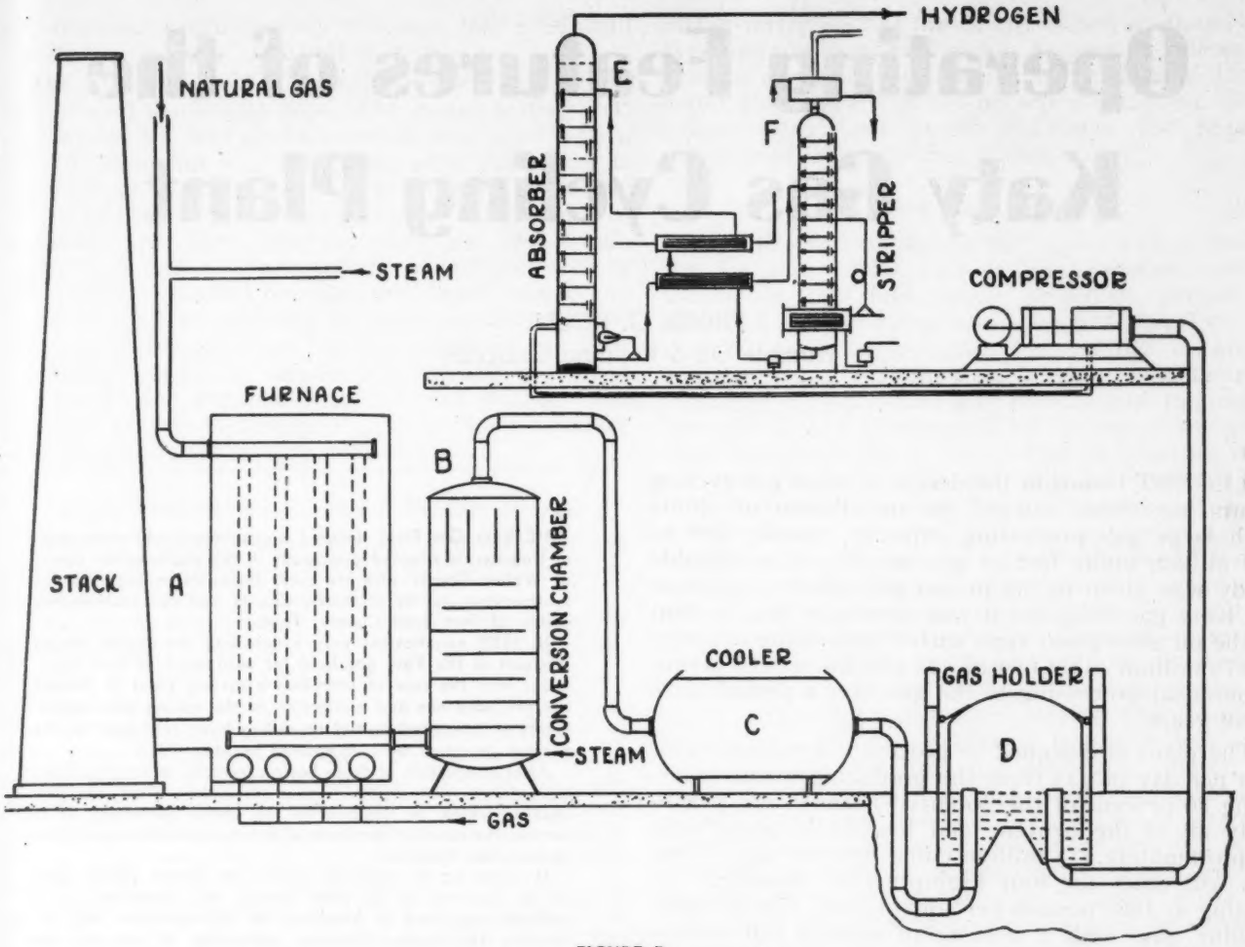


FIGURE 5
Hydrogen from natural gas by conversion process.

and may be produced by thermal cracking of lighter hydrocarbons; hexane and heptane fractions may also be catalytically reformed to these materials.

The raw materials required for the production of explosives, i.e., synthetic ammonia, toluene, etc., are not only of importance in wartime but future peacetime needs[6] should see a steady increase in the production of these and similar type raw materials with developments in chemical processing, chief of which may be the plastic industry.

The great technologic developments in hydrocarbon chemistry have made possible the production of many war products in quality and quantity to successfully supply our armed forces. Products like silk and rubber, which cannot be obtained from their natural sources, are now being replaced by synthetic rubber, plastic goods and synthetic fibers. In addition, the rapidly expanding plastic industry supplies goods to replace critical consumer products requisitioned for war purposes. In these operations natural gas and natural gasoline supply ever-increasing quantities of hydrocarbon raw materials which are of great value in the war effort.

Conclusion

The processes stated herein, in part, represent some of many processes which are now in commercial operation or awaiting commercial development. These processes reflect a much higher field of utilization for natural gas and natural gasoline other than as a fuel and source of energy and tends to dictate that their true value will rightly be recognized by the petroleum industry in the near future. These developments offer the petroleum industry new fields and processes by which it may put to efficient use a portion of its product which heretofore has received little attention. It should be remembered that these developments have come during wartime when the success of a process depends on the availability of raw material used by the efficient use of critical material required by the process. This condition appears to suggest that the majority of these processes are economically sound and the return to peace will see them established as permanent factors in national economy. Constant vigilance on the part of the petroleum industry relative to the great potential possibilities of natural gas and natural gasoline will not only materially aid in the production of war products required by our armed forces but will place this industry in a most advantageous position to convert to the production of the immense quantities of synthetic consumer goods which will most assuredly come with the return to peace.

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Operating Features of the Katy Gas Cycling Plant

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RECENT trends in the design of most gas cycling plants have been toward the installation of plants with large gas processing capacity, usually 100 to 500 million cubic feet of gas per day. Considerable study was given to the proper size plant to produce the Katy gas field, and it was concluded that a plant of the oil absorption type with a processing capacity of 275 million cubic feet of gas per day would permit economical processing of the gas over a period of 30 to 40 years.

The plant is designed to process 275 million cubic feet per day of gas from the producing wells, recovering 80 percent of the potential butanes and practically all of the pentane and heavier hydrocarbons. Approximately 235 million cubic feet per day of wet gas will enter the four high-pressure absorbers operating at 1800 pounds per square inch. The absorber residue gas, with a volume of around 210 million cubic feet per day, is to be returned by the gas engine-driven compressor units to the injection wells. The remaining plant capacity is utilized in the processing of gas for delivery to two sales gas transmission systems. The rated capacity for delivery to gas sales is approximately 52 million cubic feet per day; however, the absorption equipment is sized to accommodate a reasonable overload in order to handle peak gas sales demands.

The plant at rated capacity is expected to recover approximately 7500 barrels per day of total products. Stabilization and storage facilities are provided for the separation of (1) butanes, (2) 250° F. end-point gasoline, and (3) heavy distillate, as separate products. The expected production is 1661 barrels per day of butanes, 2689 barrels per day of gasoline and 3164 barrels per day of naphtha and distillate.

Field System

The gathering system is designed to take the unit's gas from 15 producing wells, 3 of which are dual completions. The lines are sized for a maximum daily production of 20 million cubic feet each from the edge wells, 25 million cubic feet each from the other single-sand completions, and 40 million cubic feet from dual completions. To allow for future production from the weaker and lower-pressure wells in the upper sands, the lines are designed for a pressure drop of 200 pounds, assuming 2200 pounds per square inch at the plant and 2400 pounds per square inch at the well meter settings. The gathering system is designed for a working pressure of 2700 pounds per square inch at 130° F.

Each producing well is equipped with a meter setting for metering the gas produced from each sand.

THE Katy Gas Field, located approximately 40 miles west of Houston, is situated principally in the southeastern corner of Waller County with its outer limits extending into the southwestern corner of Harris County and the northeastern corner of Fort Bend County, Texas.

In 1939, negotiations were begun with the parties having interests in the Katy gas field for unitization of their properties with the view of installing a cycling plant to process the produced gas and reinjection of the residue gas. Agreements of interested parties regarding basic contracts for the project operation were completed by May, 1941.

After completion of these basic contracts, immediate plans were drawn for installation of a gas-cycling plant, the purpose of which, in addition to the above operations, is to recover the essential products of butanes, gasoline, and other hydrocarbon fractions.

It might be of particular interest to discuss briefly some of the features of the plant design and operations as to methods employed in handling the high-pressure gas, extracting the desired butanes, processing of gas for gas sales, the unusual arrangement and operation of the steam system, as well as other design features.

This paper was presented before the Spring meeting of the Southwestern District, A. P. I. Division of Production, Houston, April 30, 1943.

For the lower-sand wells there is a single-wing casing and tubing connection with 2-inch adjustable chokes for controlling the flow. For the upper-sand single-completion wells the casing is connected by a double 4-inch wing, and the tubing by a single wing, and the tubing by a single-wing connection, equal in size to the tubing. Each wing has an adjustable choke for controlling the production rate. For dual-completion wells the well head connections are the same as for the upper-sand wells.

The system for returning gas to the injection-wells is planned so that reasonable distribution control may be maintained. Control of the gas cycling "pattern" will necessitate variations in gas-injection rates to the various wells during the period of operations. The injection field lines are designed so that approximately 50 million cubic feet could be delivered to each injection well with a maximum pressure drop of 100 pounds between the compressors and the injection-well heads. Of this pressure drop, about 25 pounds is due to line losses at the plant, expansion bends, meter setting, and well-head connections.

A comparison was made of the merits of individual lines between the plant and the injection wells as against a large line from the plant to each end of the field with laterals to each injection well. It was found in this particular case that, for a given pressure drop, the individual lines had about 25 percent more capac-

ity, required approximately 250 tons less steel, and resulted in a lower installation cost.

The injection field lines are 7⅝-inch OD (0.625 inches wall thickness) pipe. The meter setting and pipe within 125 feet of the injection well are 6⅝-inch OD (0.718 inches wall thickness) pipe. All piping is designed and constructed in accordance with the ASA Code for High-Pressure Piping, using Grade B seamless pipe. Each injection well has two 4-inch casing and one 2½-inch tubing connection with a check valve installed on each well-head connection. The field lines are securely anchored at each end and between each expansion bend provided in the line. Expansion bends are also installed at the well head to provide for expansion in the well casing. The injection system is designed for a working pressure of 3500 pounds per square inch at 175° F.

High Pressure Gas System Within Plant

Figure 1 illustrates the essential features of the plant process design and is to be referred to in illustrating the various systems involved.

The producing wells, at an average flow rate of 25 million cubic feet per day each, have a pressure at the well head of approximately 2450 pounds per square inch and a flowing temperature of 165° F. The wet gas arrives at the plant at a pressure of 2200 pounds per square inch and a temperature around 135° F. The gas, to be processed in the high-pressure absorbers and handled through the compressor unit for reinjection to the producing formation, is first cooled in the high-pressure cooling coils located in the cooling tower. Such cooling reduces the gas temperature from 135° to 90° F. at inlet plant pressure. After cooling, the gas is delivered to the 1800-pound system through two headers and pressure-reducing regulators which control the absorber and compressor suction pressure at 1000 pounds per square inch. Before introducing the gas into the four 1800-pound absorbers, it is passed through two separators operating in parallel to remove the liquid formed by previous cooling and pressure reduction. The discussion of this liquid flow will follow under "Condensate Flash and Process System."

Gas from the separators operating at 1800 pounds per square inch is next delivered and equally distributed to four absorbers operating in parallel. Sufficient absorption oil contacts the gas for the extraction, at this point, of 84 percent of the butanes. The residue gas is then passed through two scrubbers in parallel operation where any entrainment or large quantity of liquid that might be carried overhead from the absorbers, due to mechanical "upset," will be automatically collected and drained. The gas then goes into the compressors for delivery to the injection wells. All gas volumes referred to in this discussion are at a pressure base of 14.7 pounds per square inch, absolute, and 60° F. temperature.

The compressor unit has seven 800-horsepower compressors, each machine consisting of two double-acting horizontal compressor cylinders directly connected to an 8-cylinder power engine operating at 330 rpm. The compressors are installed to deliver 210 million cubic feet per day of high-pressure absorber residue gas to the injection system and wells at a suction pressure of 1800 pounds per square inch and a discharge pressure of 3000 pounds per square inch. A closed-jacket cooling-water system is provided for the unit, the make-up water being condensed steam from the power plant system. The jacket-water coolers are of the closed shell-and-tube type and are arranged with a by-pass and necessary control equipment to maintain the desired jacket-water temperature. A 100-horsepower electric motor-driven centrifugal pump circulates the required quantity of jacket-cooling water.

Sales Gas System

Facilities for supplying the high-pressure residue gas for sale to the two gas transmission systems located in the field center primarily around the operation of two 800-pound sales gas absorbers and the 600-pound high-pressure reabsorber. A stream of the wet gas from the field is withdrawn upstream from the high-pressure gas coolers and reduced to 800 pounds per square inch by means of an instrument-operated control valve. Due to pressure drop, the temperature of the gas will be lowered from 135° F. to approximately 80° F. A heater is installed in the line to prevent hydrate formation at low temperatures. The gas, along with the liquid formed by pressure reduction, is next delivered to the sales gas separator where the liquid is removed and the gas passed to the two sales-gas absorbers operating in parallel. Sufficient absorption oil contacts the inlet gas to extract approximately 79 percent of the butanes. The residue gas, after leaving the absorbers, goes to a 600-pound operating pressure reabsorber and with the recompressor discharge vapors, the total gas from this stop-tank then passes through control equipment and into the sales-gas systems. The control scheme of the system is such that either constant gas volume or constant pressure may be maintained on one of the gas systems, while gas delivery to the other system is designed for constant pressure only. A primary pressure-reducing regulator on the high-pressure inlet wet gas floats on the line so as to maintain 800 pounds per square inch on the sales-gas absorbers regardless of the variations in sales gas deliveries.

Reabsorption System

One of the major problems encountered is the design of a process employing a pressure in the primary absorbers of 1800 pounds per square inch is the proper removal of the tremendous quantities (approximately 16,000 mcf. per day) of methane and ethane dissolved in the rich oil from the absorbers. The most practical method of eliminating these undesirables, and yet retaining butanes, is by stage reduction of pressures and reabsorption of the desirable hydrocarbons. Careful consideration was given in the design to selection of the optimum pressures for these flashes and reabsorptions. As a result, the rich oil from the 1800-pound absorbers combines with that from the sales-gas absorbers and is flashed successively at 600, 200 and 35 pounds per square inch. The flashed gases are contacted at respective pressures in the reabsorber for the desired butane retention. The residue gas from the high-pressure reabsorber is delivered to the sales-gas system. The residue gas from the intermediate-pressure reabsorber is used for plant fuel, any excess being recompressed, cooled and delivered to the sales-gas system. The residue gas from the low-pressure reabsorber supplies fuel for the boilers and direct-fired heaters. It is not necessary under the above system of rich oil flashes and reabsorptions to design for a high percent butane extraction in any of the reabsorbers. The favorable result is in that the rich-oil feed to the

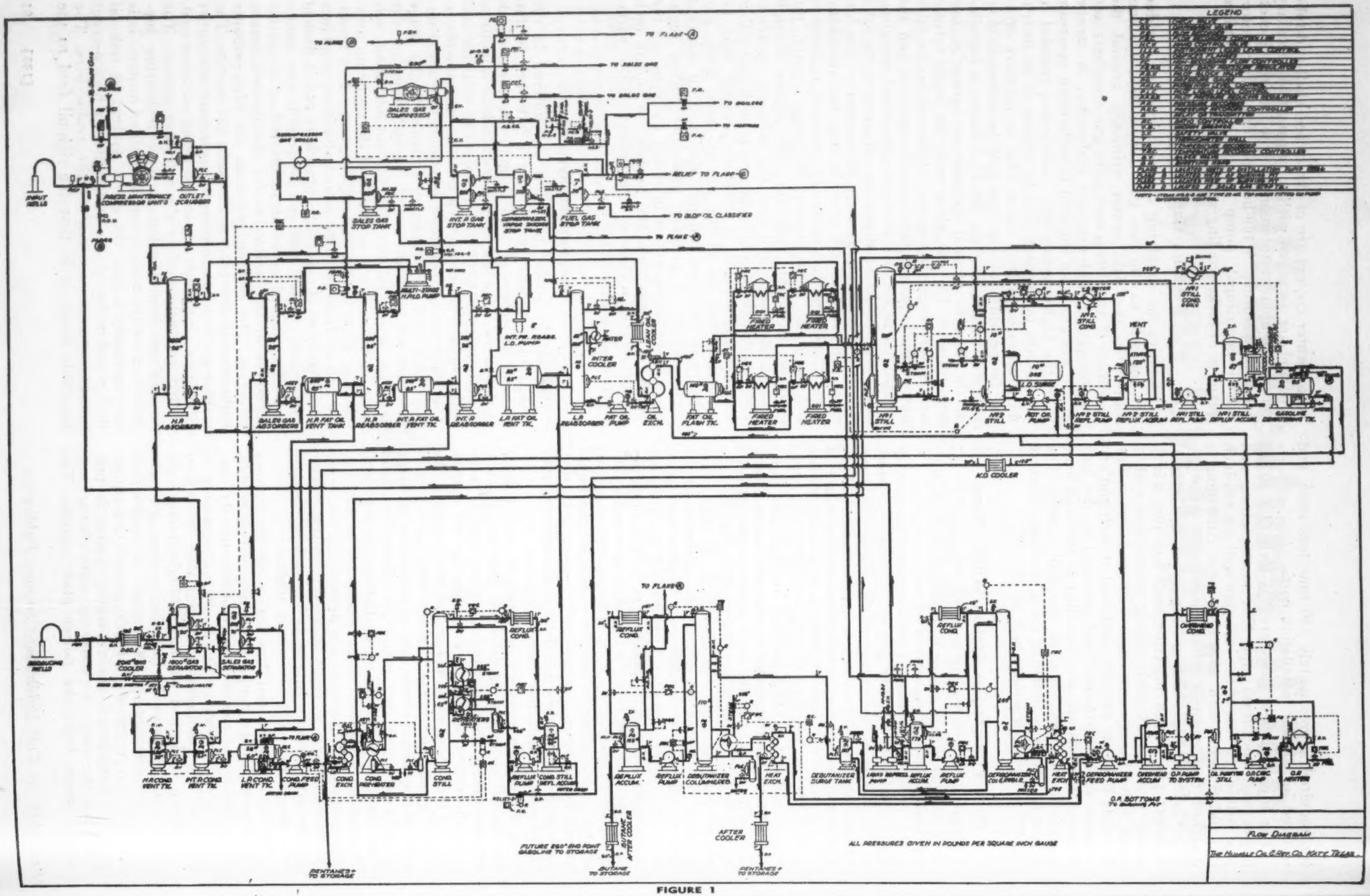

LEGEND
TO FLARE (A)
TO SALES GAS
TO SALES GAS
TO BOILERS
TO HEATERS
RELIEF TO FLARE (B)
TO SLOP OIL CLASSIFIER
TO FLARE (A)
SALES GAS COMPRESSOR
SALES GAS STOR TANK
INT. P. GAS STOR TANK
FUEL GAS STOR TANK
H.P. ABSORBERS
SALES GAS ABSORBERS
H.P. FAT. OIL VENT TANK
H.P. REABSORBER
INT. P. FAT. OIL VENT TK.
INT. P. REABSORBER
L.P. FAT. OIL VENT TK.
L.P. REABSORBER
FAT. OIL FLASH TK.
FIRED HEATER
NO. 1 STILL
NO. 2 STILL
NO. 1 STILL REFLUX ACCUM.
NO. 2 STILL REFLUX ACCUM.
GASOLINE DEBUTANIZER TK.
K.O. COOLER
H.P. COND. VENT TK.
INT. P. COND. VENT TK.
L.P. COND. VENT TK.
COND. FEED PUMP
COND. EXCH.
COND. PREHEATER
COND. STILL
REFLUX COND.
REFLUX ACCUM.
REFLUX PUMP
DEBUTANIZER COLUMN
HEAT EXCH.
DEBUTANIZER SURGE TANK
DEBUTANIZER FEED PUMP
OVERHEAD ACCUM.
O.P. PUMP TO SYSTEM
O.P. CIRC. PUMP
O.P. HEATER
AFTER COOLER
PENTANES + TO STORAGE
BUTANE TO STORAGE
FUTURE 250° END POINT GASOLINE TO STORAGE
ALL PRESSURES GIVEN IN POUNDS PER SQUARE INCH GAUGE
FLOW DIAGRAM
THE HUMBLE OIL & REF. CO. KATY, TEXAS

FIGURE 1

still system contains a minimum of dissolved methane and ethane hydrocarbons.

Condensate System

A separate system is provided for processing the liquid formed by retrograde condensation and separated from the gas in the 1800-pound and 800-pound sales-gas separators. It may be of interest to point out several of the factors which influence the selection of this design.

1. To eliminate possible future difficulties with salt water of other contamination of the absorption-oil system.
2. To relieve the steam-stripping loads on absorption-oil stills.
3. To permit partial operation of the plant when units of the absorption plant are shut down.
4. To give added flexibility for varying the end-point of the gasoline product.

The liquid separated in the 1800-pound inlet-gas separators is flashed into the sales-gas separator, operating at 800 pounds per square inch. This permits reabsorption of the flashed gases at optimum pressure and reduces the quantity of field wet gas required to supply the sales-gas demands. The 800-pound separator liquid is further flashed in stages to 600, 200 and 35 pounds per square inch, the flashed gases going to the previously mentioned reabsorbers operating at these respective pressures. In this manner, all of the flashed vapors are properly processed in the reabsorption system for the retention of the desirable butanes. The liquid from the low-pressure condensate flash tank is delivered by pump through heat exchangers, a preheater, and into the condensate still operating at 45 pounds per square inch. Sufficient stripping steam is introduced into the base of the still to effect the removal of all the 250° F. end-point and lighter hydrocarbon fractions, the overhead vapors passing through a condenser where approximately 90 percent condensation is obtained. External reflux is returned by the reflux pump to the top of the still for the desired end-point control of the overhead product, while the net overhead product is introduced as liquid into the vapor stream from No. 1 still, just upstream of the final-product condensers. The product from the base of the condensate still is heat exchanged against the feed material and then delivered to storage as gasoline-free distillate.

Distillation System

The primary purposes of the distillation system are to process the rich oil from the absorption unit, remove the desired gasoline fractions, and provide a well stripped heavy absorption oil for recirculation to the absorption system. To accomplish these, it is necessary to operate a two-still system. The No. 1 still, operating at 90 pounds per square inch, is designed to remove the 250° F. end-point gasoline product from the rich oil. This is accomplished by pumping the rich oil from the absorption system through heat exchangers and direct-fired heaters to bring the temperature level to 530° F. Sufficient stripping steam effects the removal of the desired overhead fractions while a hot reflux controls the gasoline final boiling point. The liquid condensed from the overhead of this still provides the raw charge to the stabilizers.

Oil leaving the base of the No. 1 still contains hydrocarbons boiling between 250 and 500° F. The No. 2 still, operating at 5 pounds per square inch, receives this oil feed for further processing at approximately 500° F. Sufficient stripping steam removes the heavy hydrocarbons and gives control on the initial boiling point of the absorption oil from the bottom of the still. The stripped absorption oil is next pumped through the heat exchangers and final oil coolers and to the various absorbers. The overhead product is condensed and delivered to storage with the bottoms from the condensate still.

The absorption oil for the sales-gas absorbers and the high-pressure reabsorbers is withdrawn as a side stream from the main high-pressure lean-oil pump. The pump for delivering the oil to these absorbers is a 1900-horsepower steam-turbine-driven centrifugal unit. It is designed to handle a normal load of 1340 gmp., 250 gpm. being withdrawn at 800 pounds, while 1090 gpm. is pumped to the four high pressure absorbers operating at 1800 pounds per square inch. The total absorption-oil circulation for the plant amounts to 1673 gallons per minute of 36 degree API-500° F.-initial-boiling-point-oil.

Stabilization Unit

The stabilization unit is designed to produce two finished products. They are (a) a mixture of butanes, with or without propane, and (b) a butane-free specification end-point gasoline. These products, in addition to the heavier fractions from the distillation system, constitute the plant's total production.

The stabilizer scheme followed in the plant design is similar to the arrangement of most stabilizer installations. However, the depropanizer unit has one particular feature which is seldom found in other plants of this nature. The raw gasoline feed material, containing a small quantity of methane and ethane hydrocarbons, is pumped into the depropanizer operating at 285 pounds per square inch. Practically total condensation is obtained on the overhead material of propane and lighter hydrocarbons upon cooling this stream for reflux.

A turbine-driven triplex repressuring pump with 285 pounds suction pressure and 3400 pounds discharge pressure will handle all excess reflux, thus permitting the return of this material as a liquid into the discharge header of the main gas compressors and hence to the injection wells. This method of operation affords a saving in investment as well as the elimination of a recompressor, thereby reducing the operating expenses.

The liquid from the depropanizer reboiler, consisting of the butanes and heavy hydrocarbons, is next fractionated in the debutanizer column. Here the butanes are removed as an overhead specification product, while the final gasoline is withdrawn as a bottom product. The butanes are condensed and transferred to two 5000-barrel spherical tanks for storage while the gasoline fraction is cooled and delivered to three 5000-barrel spherical storage tanks.

Steam and Power System

Humble Pipe Line Company has a pump station located on the plant site to handle deliveries of the plant products to the Baytown plant of Humble Oil & Refining Company. The butane product is pumped to the Satsuma-East Texas gasoline line through 17 miles of 4-inch pipe. The gasoline and heavier products are pumped through 9 miles of 4-inch pipe line to the Raccoon Bend Pumping Station.

The steam and electric system for the Katy Gas-Cycling Plant is quite unusual as compared with that encountered in most plants of this nature. During the

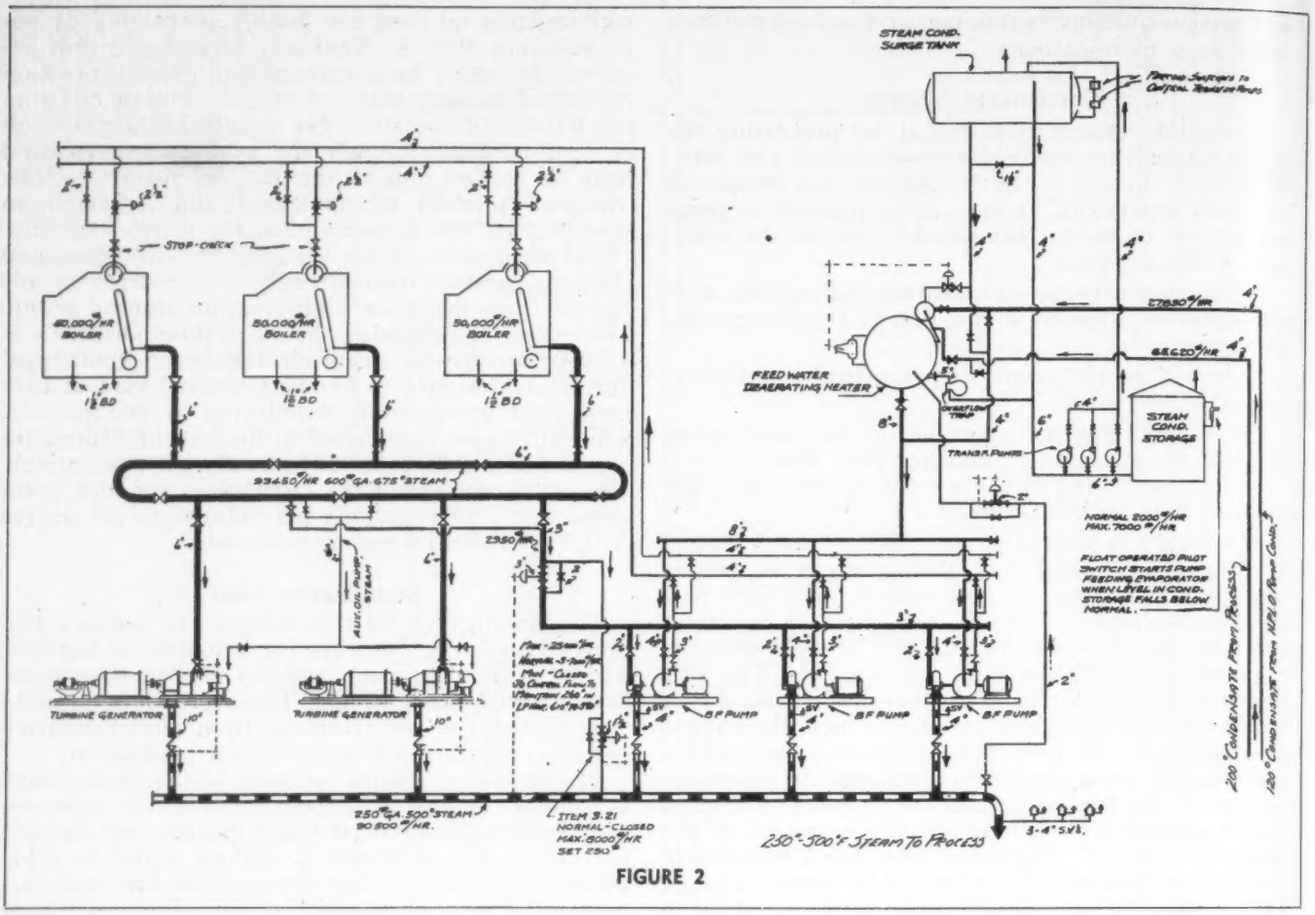


FIGURE 2

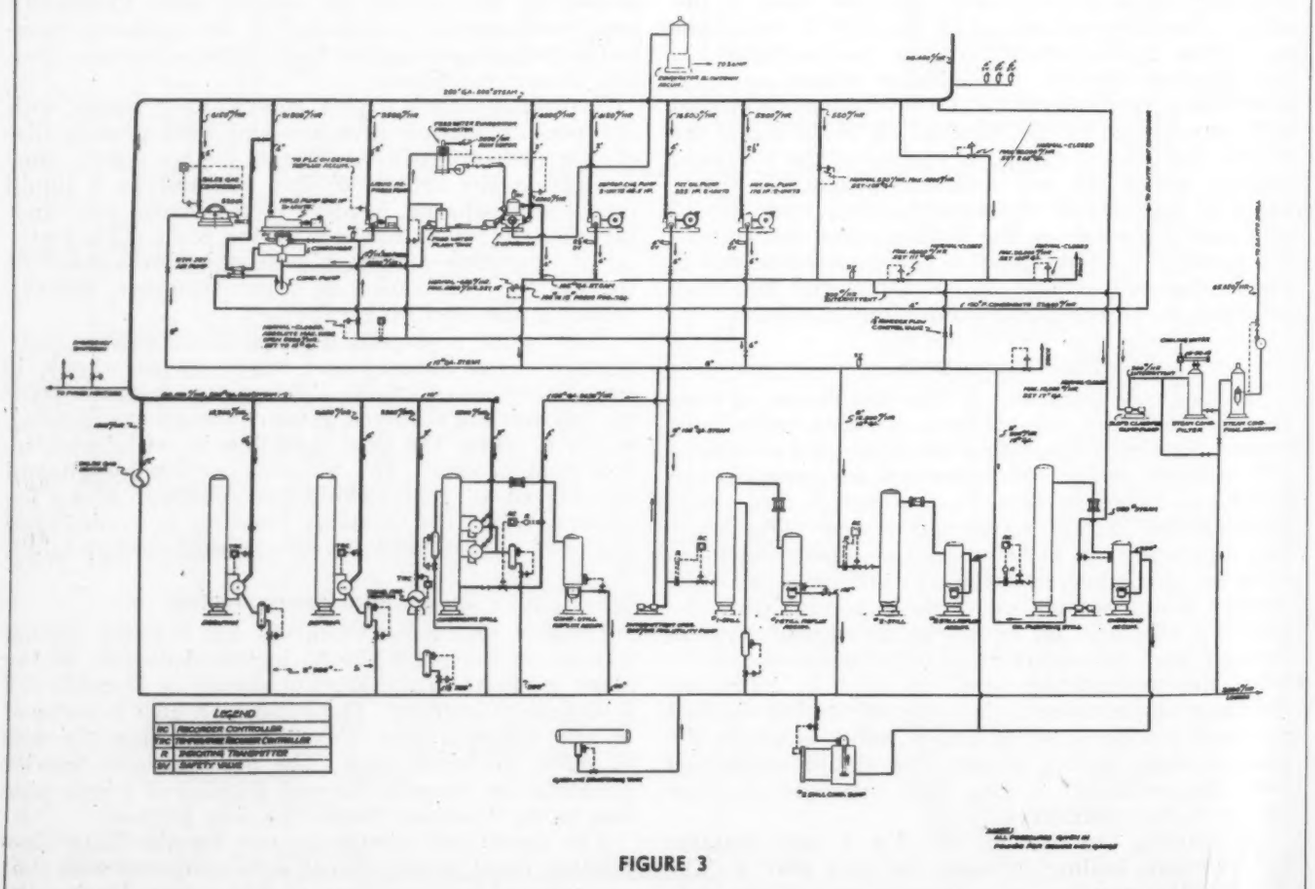


FIGURE 3

preliminary discussions of the plant design, it was decided to use steam and electrically-driven centrifugal pumps where practical. The plant process required approximately 95,000 pounds of steam per hour at 250, 105 and 15 pounds per square inch pressure, and an electric power and lighting load of 1740 kw.

Comparisons were made of the various combinations of steam and electric drives for the different services and combinations of condensing and non-condensing steam plants operating at 250 and 600 pounds per square inch steam pressure. These comparisons included installation and operating costs and trial heat balances.

After analyzing the various power schemes, the most attractive was the generation of steam at a pressure of 600 pounds per square inch, generating the required electrical load by back pressure-steam turbine-driven generators, and staging the steam pressures down through the plant so that the total steam required for the generator drives balanced the requirements for process heating, stripping, and pump drives.

A brief discussion of the steam system will illustrate the principal features of interest. Figure 2 shows the arrangement in the power plant, while Figure 3 details the methods of utilizing the steam in the distillation system.

To meet the processing requirements of steam, three 700-pound working pressure boilers are installed. Each boiler is designed to produce 50,000 pounds per hour steam at 600 pounds pressure and 675° F. temperature. The boilers are of the integral furnace type, completely water walled, and equipped with forced and induced draft fans with stub stacks.

For the calculated electrical load of 1,740 kw., there are installed two 2,000-kw., 440-volt, 3-phase, 60-cycle, 3600 rpm. turbo-generators. The turbines operate at 600 pounds inlet steam pressure and throttle to 250 pounds back pressure. Normally, two boilers and one turbo-generator will be operated.

Steam from the 600-pound header is used to drive the generator and boiler-feed pump turbines, the exhaust pressure from these turbines being maintained at 250 pounds per square inch. The exhaust steam at 250 pounds per square inch is next utilized in the distillation unit process for heating, stripping and driving certain pumps. The steam as utilized in these services is all condensed and returned to the deaerating heater for feed to the boilers. An elevated surge tank maintains constant make-up water to the heater and any excess water overflows to the storage tank. The pumps at the storage tank are operated automatically to maintain proper water level in the surge tank, while a float-operated switch controls the operation of the make-up evaporator to maintain constant water level in the tank.

There are three dual-drive centrifugal feed-water pumps, operating at 3550 rpm. each, driven through a flexible coupling by a 150-horsepower motor at one end and by a steam turbine at the other end.

An automatic regulating valve in the steam line to the three turbines divides the power input to the pumps between the turbines and motors for the purpose of controlling the steam pressure in the 250-pound exhaust header.

Complete automatic combustion control equipment is installed on each boiler for maintaining pressure, forced draft, furnace draft and induced draft.

The distribution and utilization of the steam from the boiler house at a pressure of 250 pounds per square inch is one of the most interesting systems in the plant. Approximately 56,450 pounds per hour of steam is required for driving the various pumps in the distillation system while 36,450 pounds per hour are utilized in heating in the stabilizer reboilers, the condensate-still preheater and reheaters. A steam demand of approximately 25,000 pounds per hour at a pressure of 105 pounds per square inch is required for stripping in the No. 1 still and condensate still. The turbines driving the fat-oil pumps and the depropanizer charge pump are of the back-pressure type, exhausting into 105-pound steam header. The steam from the make-up evaporator goes into this header. The 105-pound steam is next used in stripping as illustrated. The quantity of stripping steam required at 15 pounds per square inch is 12,700 pounds per hour. To provide this steam, the turbines driving the hot lean-oil pump and recompressor exhaust into a steam header operating at 15 pounds per square inch. The pressure in the 15-pound steam header is controlled by means of a pressure-reducing regulator from the 105-pound system. Sufficient regulating and relief-valve equipment is installed to prevent excessive pressure in any of the steam headers during either partial or full-load operation.

The centrifugal oil pump, delivering absorption oil to the high-pressure absorbers, is driven by a 2000-horsepower steam turbine operating at 3600 rpm. The inlet steam is at a pressure of 250 pounds per square inch, while the turbine exhaust steam is piped into a 2800-square-foot surface condenser operating under four inches mercury back-pressure. The exhaust steam from the turbine driving the liquid repressuring pump along with any excess steam from the 15-pound steam header is also introduced into this surface condenser. The condensate from the hot well of the condenser is returned by pump to the deaerating heater in the power plant.

The condensed steam from the various units of distillation equipment is returned to a steam condensate filter and separator system where any trace of oil or contamination will be removed and the condensate returned by centrifugal pump to the deaerating heater located in the boiler plant.

This method of operation assures practically total return of condensed steam for feed to the boilers. The expected make-up requirement is less than 5000 pounds per hour.

Electrical

The main switch board located in the power plant is of the dead-front, metal enclosed type with draw-out circuit breakers and interconnecting bus structures for the control of the underground system rated at 440-volt, 3-phase, 3-wire, 60-cycle current. Main generator and feeder-panel breakers are electrically operated with the distribution-panel breakers being manually operated with inverse time delay trip and several are equipped with shunt electric trip.

Two sets of underground cables are run in separate fiber ducts buried in concrete to separate bus ducts in the switch houses located near the cooling tower, distillation unit pump building and the compressor building, each set being protected by a circuit breaker in the power house. In order to insure continuous operation of these essential units, half of the motor load at each center will be on the breaker located on distribution board "A" and half of it on board "B." Motor load in the power plant is divided in the same

manner. The system is balanced so that the entire load is almost exactly equal on the two feeder breakers.

Each motor at load centers has an explosion-proof push button near it. Standard line starters and circuit breakers are located in the switch houses.

Plant Safety Features

The necessity for providing safety devices in an average gasoline plant is obvious. In a large high-pressure cycling type plant, it is of utmost importance to give particular attention to safety features. The safety arrangements although sometimes very simple, act as guards to warn of trouble, and also to protect the equipment against damage. There are many safety features of interest in the Katy plant, a few of which will be briefly discussed.

1. *Emergency high pressure gas control system:* In order to protect the plant in case of some failure in the high-pressure-gas system, piston-operated plug valves are installed on both the producing and injection lines at the plant boundary. These valves are operated from a series of manually-operated control stations strategically located in the plant operating area. Such operation will shut off the incoming and outgoing gas, as well as shutting down the compressor unit. At the same time, another piston-operated valve will open to permit the blowing down of the high-pressure gas within the plant to a flare stack located on the south boundary of the plant yard.

2. *Protection of direct-fired heaters:* The direct-fired heaters have both a hand-operated steam snuffing system and an emergency snuffing system, which may be operated in case of tube failure or fire. As a protection against the loss of oil flow through the heaters, which may happen in the event the rich-oil pump fails, the fuel gas will automatically be shut off, thus reducing the hazard of coking up the heater. A third feature is that a failure of fuel-gas supply will automatically close the fuel regulator which must be manually reset, thus eliminating a fire hazard.

3. *General alarm system:* In order to warn the plant operator of trouble in the system, an arrangement of alarm whistles is installed on the various vessels requiring special attention against certain adverse operating conditions. However, if the problem is beyond the operator's control, another set of safety controls will automatically shut down the major mechanical equipment, thus insuring protection against damage.

Cooling Water System

In a cycling plant of usual design, having the capacity of the Katy plant, the quantity of cooling-water circulation would be approximately 20,000 gpm. By a careful balance of heat requirements and equipment installation, the Katy plant requires only 14,000 gpm. This reduction is a result of balancing the cooling loads for the closed shell-and-tube type condensing and cooling equipment against the cooling required for the atmospheric cooling sections located in the base of the cooling tower. Approximately 14,000 gpm. is required over the coils in the cooling tower. The water in passing over these coils increases in temperature from 85 to 95° F. This 95° F. water is then pumped in parallel flow through the shell and tube equipment of (1) Engine Jacket Water Coolers, (2) Exhaust Steam Condenser, (3) No. 1 Still Primary Reflux Condensers, and (4) No. 2 Still Primary Reflux Condensers. The water, after passing through these units, is delivered over the top of the cooling tower for distribution and reduction in temperature from 115 to 85° F., thus completing the cycle of water flow.

Raw water for the plant make-up is supplied from water wells in the plant yard. A 500-gpm. pump delivers water from the water wells to a 3000-barrel settling tank. This make-up water, in its route to the cooling tower, is utilized for cooling in the low-pressure reabsorber intercooler and various other minor cooling duties required in the power and distillation unit equipment. The raw water supply is also connected to the plant camp and to all fire systems.

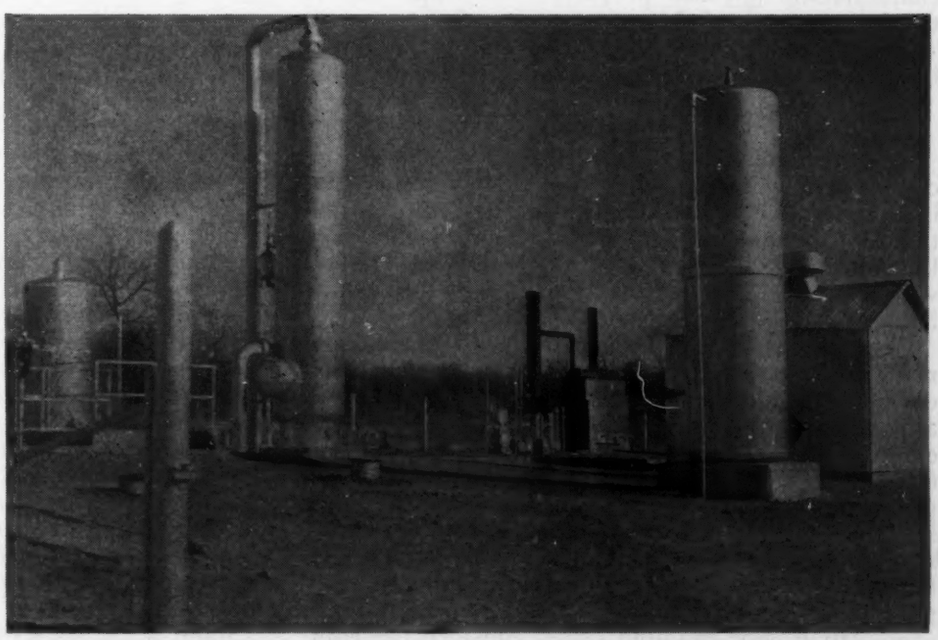
Diethylene Glycol Absorbent For Hydrate Removal

REMOVAL of entrained moisture and water vapor from natural gas is being successfully and inexpensively accomplished by a large utility company in a small specially designed semi-automatic plant employing diethylene glycol as an absorbent. The gas is produced from a formation carrying large quantities of water around the edges of the field and in the lower sections of the zone, which causes all of the fuel to be wet in the sense that excessive water vapor is suspended or absorbed. Pipeline drips between the dehydrating station and the wells in the field accumulate and remove condensate and free water, but are, in themselves, not adequate to fully condition the gas for pipe-line transmission.

To prepare the pipe line to receive the dehydration plant, a section was removed and replaced with a master gate and a by-pass manifold which includes the absorption-column piping. The column acting as the absorber has sufficient baffles and bubble plates to insure adequate contact between the gas and the absorbent. The flow of gas is conventional, entering the base of the column and passing out at the top, both inlet and outlet being served by short lines to prevent excessive use of pipe and fittings. A direct-connected outside-mounted float cage and control valve maintain a level of the absorbent in the column, perhaps one third the distance from the base to the top, so that a turbulent contact can be obtained between the gas and the diethylene glycol.

A reconditioning unit for the absorbent it located in the extreme corner of the plant yard to remove the heating element as far as practicable to insure greater safety. The unit contains two major parts, the heater and the fractionating column. The heater is a tubular-equipped furnace fired by two burners with the interior piping arranged to permit the water laden absorbent to flow up and across to the outlet connected to the stripper, or fractionator. The fractionator is a small, short column mounted on a support of piping welded to saddles at the top upon which the base of the column is set. A concrete foundation supports the column and supporting members. The temperature required to separate the water absorbed by the glycol is controlled by a thermostat with the actuating element installed in a thermometer well a few feet below the water-vapor outlet, reacting to admit more or less fuel to the heater as the temperature varies, but actually holds a constant temperature on the column above the inlet from the heater. Due to the wide difference of the boiling point of water and diethylene glycol, the only means of losing absorbent is by mechanical carry-over. To reduce any hazard of waste, a small line with a double manifold is installed to permit reflux to be pumped to the top of the column which is effective in that a choice of two points is available, the use of either being governed by tests of the water condensate from the overhead line to determine its glycol content. Diethylene glycol has a great affinity for water and is miscible in any proportion, but readily separated by the application of heat.

The water-free diethylene glycol flows from the base of the stripping column to a surge tank. Pumps to handle the absorbent are set in a small steel building between the surge tank and the reconditioning unit and are electrically-driven centrifugal units equipped with controllers which are set to maintain a constant flow of the absorbent to the absorption column. Since the volume of gas obtained from the wells is practically constant, the unit requires little attention after it has been placed in operating equilibrium.



Dehydration plant using diethylene glycol to remove water vapor from gas.

Developments in the Analysis Of Hydrocarbon Gases by Means Of Adsorption Fractionation

NELSON C. TURNER, Frick-Reid Supply Corporation

Before the annual meeting of the Natural Gasoline Association of America, Dallas, April 14, 1943

THE rapid technological advance in recent years of the natural-gasoline and other industries working with light hydrocarbons has brought with it an increased demand for more precise methods of analysis of these light-hydrocarbon mixtures.

Present methods of analysis rely almost entirely on low-temperature fractionation which requires, in order to obtain reproducible results, a highly skilled operating technique which is not available in every laboratory. Furthermore, low-temperature fractionation requires as a cooling medium either liquid air or liquid nitrogen which is not easily obtained in many sections of the country. It was these difficulties which prompted this investigation of another potential method of light-hydrocarbon analysis.

An analysis of this type can logically be separated into three different steps, which are more or less independent. The first and probably the most complex is that of the separation of the mixture into its individual components. The second step is the identification of those components by measuring some characteristic physical property. The third step is the measurement of the quantity of each component.

The procedure described below has accordingly been divided into these three steps.

Separation

Separation of hydrocarbons is most commonly accomplished by means of fractional distillation, that is, the sample is liquefied and then distilled in a fractionating column. Reflux in the column is obtained by condensing a portion of the overhead product with some low-temperature cooling medium such as liquid air or liquid nitrogen.

Generally speaking the separation of the components of a mixture by means of fractional distillation depends upon the fundamental requirement that at any point in the system where two phases are in equilibrium the composition of one phase must differ from the other. In the ordinary fractional-distillation process one of these phases is a liquid and the other a vapor, but separation by fractionation is not necessarily restricted to processes involving only vapor-liquid equilibrium. Separation is at least theoretically possible when any two phases in equilibrium differ in composition. For example let us consider the equilibrium existing in a system containing two or more hydrocarbons and activated charcoal. We have here what we may call an adsorbed phase whose composition differs markedly from the unadsorbed phase with which it is in equilibrium. It should, therefore, be possible by some means or other to take advantage of this difference in composition of the adsorbed and unadsorbed phase to effect a complete separation of the hydrocarbon components of the system.

Using this principle we can, mentally at least, conceive of a fractionating device perfectly analogous to the conventional liquid-vapor type fractionating column; if instead of condensing the reflux we had adsorbed the overhead vapor in activated charcoal and returned the charcoal to the top of the column where by some purely hypothetical means it could be made to flow down through the column, maintaining equilibrium with the ascending vapors. The reboiler in the column instead of merely boiling liquid would be used to drive all of the adsorbed material from the charcoal, which could be then ejected from the base of the column. The actual mechanical difficulties in carrying out such a process are obvious. We have, however, been successful in utilizing this principle in an apparatus which differs considerably from the conventional fractionating column in actual physical arrangement. The fundamental difference lies in the fact that we make no attempt to mechanically move the charcoal, but shift the mass of hydrocarbons and the means of heating instead. This is illustrated in Figure 1 which shows diagrammatically four stages in the process of separation of a two component mixture, such as for example methane and ethane.

Stage No. 1 shows the approximate distribution of the two components immediately after being introduced into the bottom of the column. The methane is represented by means of circular symbols and the ethane by means of crosses. It will be noted that the methane has penetrated through to the top of the column while the ethane has not penetrated more than half way up. Methane is present throughout the entire length of the column but decreases somewhat in concentration in the lower section. The ethane increases in concentration somewhat near the bottom of the column, but does not exist in a pure state at any point.

Stage No. 2 shows the changes in composition at various levels when heat has been applied at the

base. The whole body of hydrocarbons has been driven up the column a short distance. If we consider only the relative change in position of the hydrocarbon body and the charcoal bed, we may see that the upper portion of the column, which contained only charcoal saturated with methane, is available as reflux and this reflux is moving downward relative to the position of the heater and the zone of hydrocarbons containing both components. It will also be noted that this zone which is common to both components has narrowed somewhat and an area containing pure ethane has appeared just above the heater.

Stage No. 3 shows the separation at a still more advanced state. Attention should be called to the mercury reservoir attached to the heater, which allows a column of mercury to flow into the column and fill all space below the heater to prevent any down-flow and readsorption of the gases.

Stage No. 4 shows practically complete separation between the methane and ethane. The zone containing both components has narrowed into insignificance and as the heater continues to progress up the column a well defined break point will occur when the ethane reaches the top.

For purpose of clarity the actual portions of the column as shown in Figure 1 are considerably altered. The actual column is approximately 6 feet long. The inside diameter at the bottom is approximately ¾-inch and the column is tapered to an inside diameter of approximately 3/16-inch at the top. We have found that this tapering considerably increases the sharpness of separation, due apparently to the fact that the zone between two adjacent components, which contains both components, reaches a small but finite minimum thickness which is independent of the diameter of the column. Thus, by gradually reducing the diameter of the column we are able to reduce the total quantity of components which still remains as a mixture. This quantity is negligible when expressed as a percentage of the components being separated.

The circumferential fins shown on the column in Figure 1 all have the same outside diameter and these fins serve two purposes. First, they increase the rate of heat transfer between the heater and the column and, second, they serve as a seal between the heater and the column, which prevents convection air currents from passing up between the heater and the column which would tend to heat the column considerably above the heater. We have found that the sharpest separation is obtained when the zone of heating is highly localized.

For simplicity, we have confined the discussion

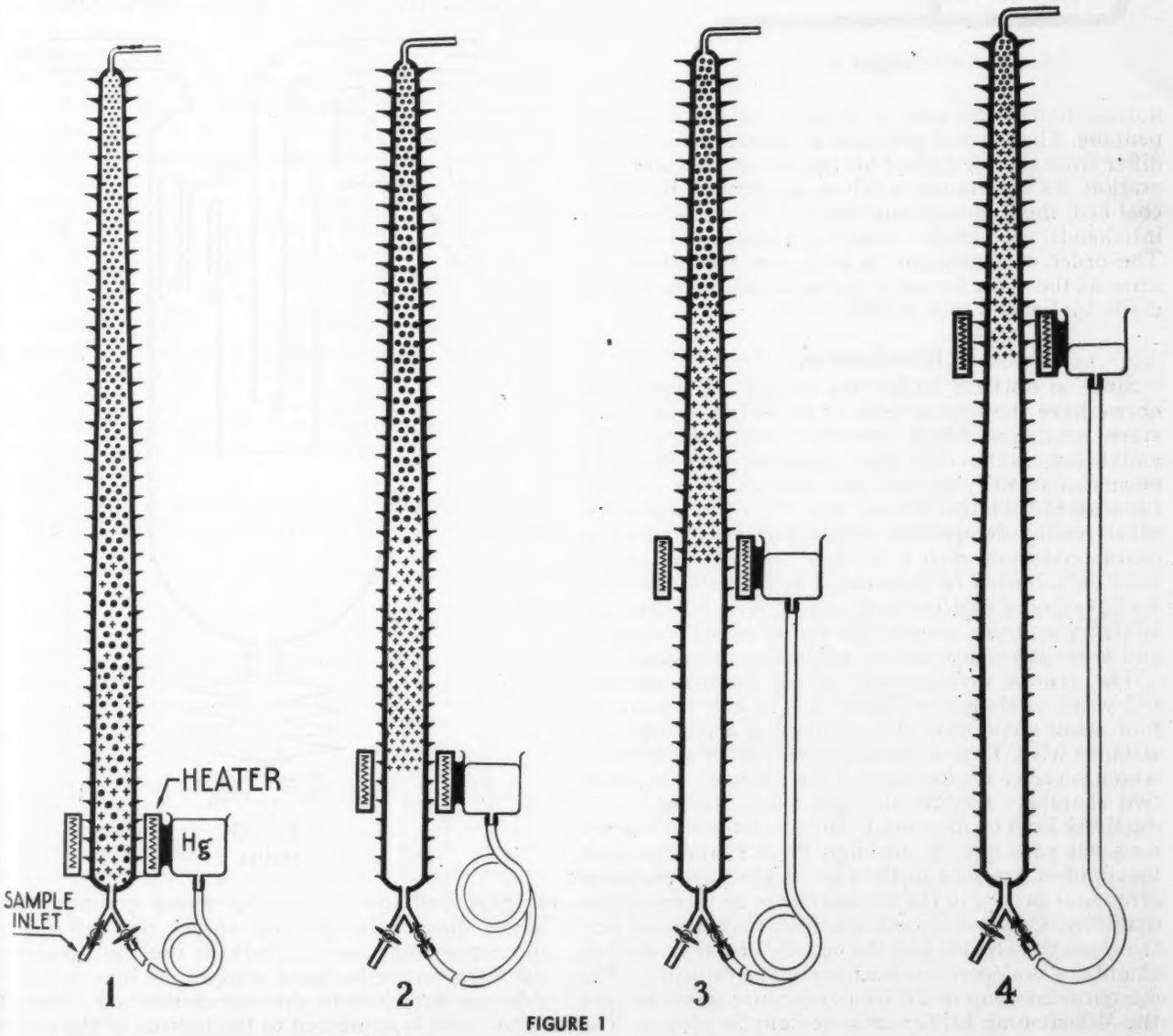


FIGURE 1

so far to the separation of two components. However, we have encountered no difficulty in separating the components of a gas sample containing all of the paraffin hydrocarbons up to and including hexane. Well defined break points occur between iso- and

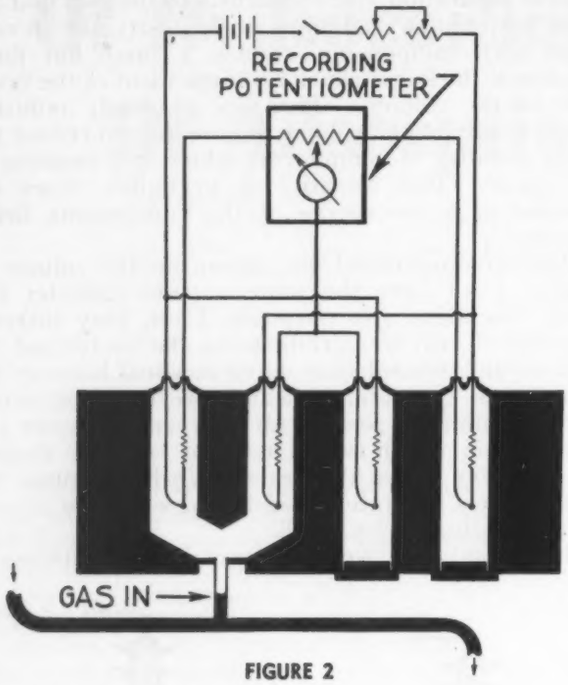


FIGURE 2

normal butane, as well as between iso- and normal pentane. The general principle of separation does not differ from that described for the two component separation. As the sample is driven up through the charcoal bed, the hydrocarbons tend to divide themselves into bands, each band containing a single component. The order of separation is with few exceptions the same as the order in which the separation would be if made by liquid-vapor fractionation.

Identification

Since at no time during the process of separation do we have the lighter hydrocarbons in a true liquid state, we are unable to measure their boiling point and hence cannot use this physical property as a means of identifying various hydrocarbons as they come off the column. We are thus forced to seek some other readily determined physical property which is characteristic of each individual hydrocarbon to be used as a means of identification. For this purpose we have found that thermal conductivity is quite satisfactory and this property is rather easily measured and is readily adaptable to automatic recording.

The general arrangement of the thermal conductivity cell is shown in Figure 2. The cell consists of four small chambers, each containing a platinum resistance wire. Two of the chambers are filled with air which serves as a standard of comparison. The other two chambers contain the gas whose thermal conductivity is to be measured. The gas from the column does not pass directly through these chambers since inevitable variations in the rate of gas flow produces erroneous results in the measurement of thermal conductivity. One end of each chamber is connected into the main gas stream and the change of gas in the cell chambers is dependent entirely upon diffusion. The electrical hook-up of the four resistance wires follows the Wheatstone bridge arrangement as shown. The balancing of the circuit is accomplished by means of a standard recording potentiometer, thus when the thermal conductivity of the gas in the two chambers changes the resistance wires change in temperature and consequently in resistance. This throws the circuit out of balance which is automatically restored by the potentiometer. The position of potentiometer is recorded continuously on a strip chart. A different reading being obtained on the potentiometer for each hydrocarbon passing through the thermal conductivity cell. The clock mechanism ordinarily used to drive a recording potentiometer has been removed and a chart-driving mechanism has been substituted, which controls the chart movement as a function of a volume of the gas coming from the top of the column. This chart drive will be described in more detail further on in this paper. The gas chambers of the thermal conductivity cell are provided with a manually-operated valve arrangement so that air can be introduced into those two chambers as a means of periodically checking the calibration of the thermal conductivity measuring system.

Quantitative Measurement

The gas stream after leaving the thermal conductivity cell passes into the metering device illustrated in Figure 3. This "volumeter" consists essentially of

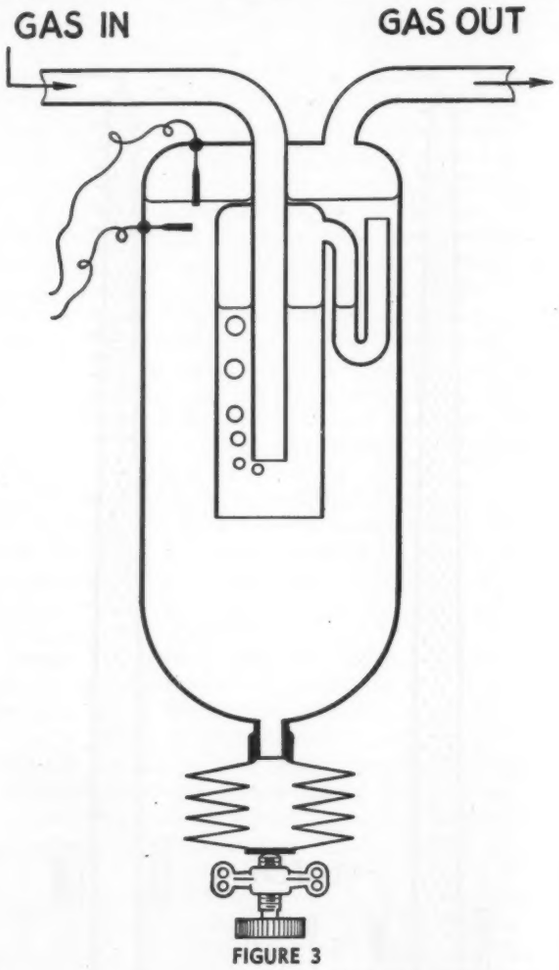


FIGURE 3

a glass bell inverted under water contained in a larger glass cylinder. Gas enters the bell through the center tube and collects in the top, depressing the water in the bell and, also, in the inverted siphon side-arm attached to the top of the bell. When the water level is depressed to the bottom of the inverted

siphon side-arm, gas breaks through and discharges into the outer cylinder. The water level in the bell is then restored to its original position near the top. Each time the bell discharges, the water level in the outer cylinder changes slightly and breaks an electrical contact between the water and an electrode fused into the outer cylinder. The interruption of this electrical circuit, operating through a relay, energizes a solenoid operated ratchet in the recording potentiometer moving the chart one increment. The increment of measurement between each discharge of the bell is approximately 4 ml. The device has been checked against known volumes of gas and an accuracy greater than one-fourth of 1 percent is consistently obtained. The accuracy of the apparatus is not impaired by variations of the rate of flow between 0 and 30 ml. per minute.

Operation

A simplified flow diagram of the entire apparatus is shown in Figure 4. The sample of gas is introduced through the flow meter into the bottom of the column. The flow meter is used to estimate the quantity of sample taken. The best quantity to use depends somewhat on the nature of the gas, ordinary dry natural gas requires about a 5-liter sample. After the sample is introduced, the sampling stop-cock is closed and the one leading to the mercury reservoir is opened. A single switch on the panel board starts the operation which from this point is fully automatic. The pulling of the switch turns on the heater which remains stationary until the temperature reaches 750°F. At this point the elevating mechanism goes into operation and the heater gradually rises at a predetermined rate which was set on the instrument panel before the apparatus was put into operation. This rate is such that the heater travels the entire length of the column in about 8 hours. On reaching the top of the column the heater remains stationary for 20 minutes, during which time hydrogen is introduced in the top of the column to act as a purge for the thermal conductivity cell, volumeter and connecting tubing. At the end of this time the heater returns to the bottom of the column at an accelerated rate. Also, the mercury level in the column returns to the bottom. Hydrogen follows the receding mercury and is present in the column when the next sample is charged in.

This hydrogen is generated in a small electrolytic cell incorporated as part of the apparatus and derives its energy from rectified 110-volt AC current. Gas leaving the top of the column during the distilling period first passes through a small graduated condensate separator. This separator together with the thermal conductivity cell and volumeter are all enclosed in a thermostatically-controlled air bath held

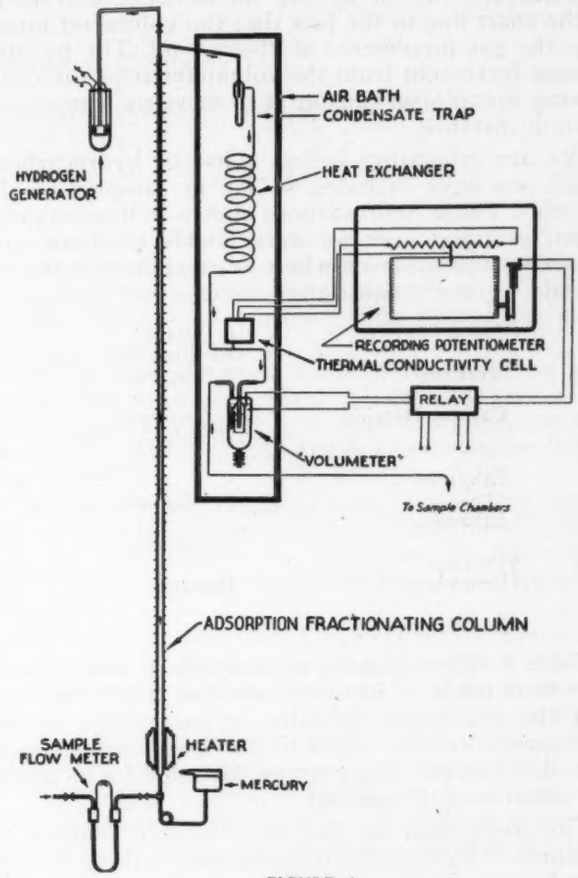


FIGURE 4

at 104°F. At this temperature all hydrocarbons lighter than hexane pass through the system as vapors and are measured as such. Hexane and heavier hydrocarbons collect in the condensate separator where they are measured as a liquid. The coiled tubing between the condensate separator and the thermal conductivity cell serves as a heat exchanger bringing the gas from the column to the same temperature as the

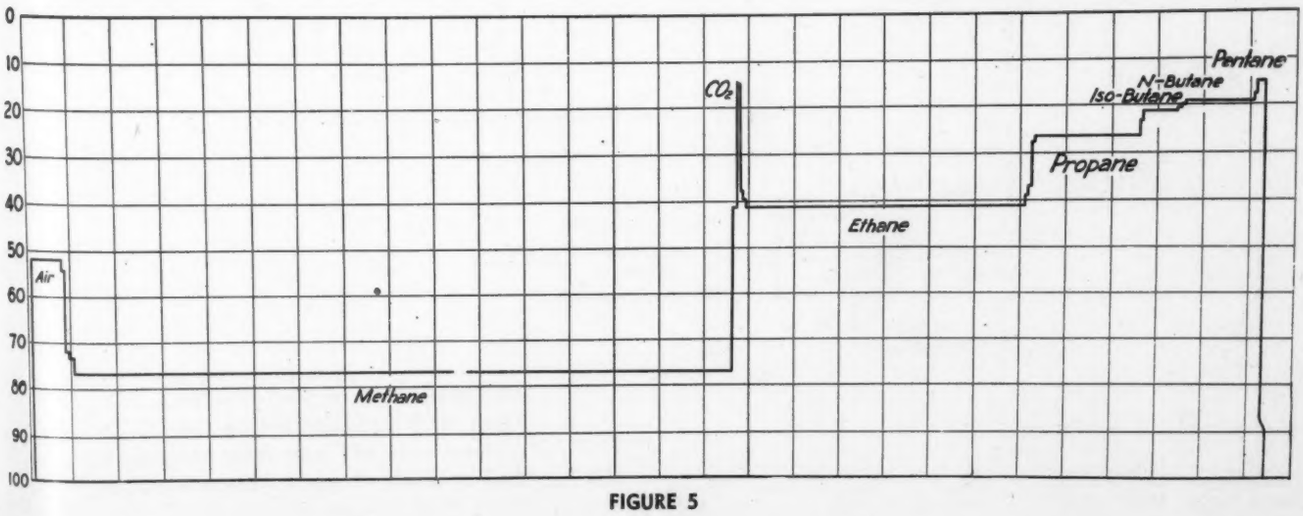


FIGURE 5

air bath, thus assuring a constant temperature of the gas entering the thermal conductivity cell.

Figure No. 5 is a copy of a complete chart recorded from the analysis of dry natural gas. A large portion of the methane line has been taken out in order to make a cut of more printable proportions. The small plateaus are caused by the intermittent movement of the chart due to the fact that the volumeter measures the gas increments of about 4 ml. The passage of each increment from the volumeter trips the chart driving mechanism causing it to move up a small but definite distance.

We are tabulating below a list of hydrocarbons which we have included so far in samples to the columns. Those hydrocarbons shown in brackets represent groups where we were unable to obtain any apparent separation or where separation was too indefinite to be of quantitative value.

Air	{n-Butane {iso-Butylene
Methane	{1-Butylene
Carbon Dioxide	{2-Butylene {Butadiene
Ethylene	
Ethane	iso-Pentane
{Propane {Propylene	n-Pentane
Iso-Butane	Hexane

Table 1 shows a series of analyses in which check runs were made on identical samples. It will be noted that the maximum deviation in percentage of one component does not differ in the check analysis more than 0.69 percent. The average deviation for all analyses shown is 0.155 percent.

The work thus far has been largely confined to mixtures of hydrocarbons containing nothing heavier than hexane. Analysis of mixtures containing known quantities of hexane have demonstrated that this hydrocarbon can be adsorbed in the column and quantitatively recovered in the distillation. Similar runs made with samples containing known quantities of heptane and heavier hydrocarbons show that these

Check Analysis of Two Types of Hydrocarbon Mixtures

DRY NATURAL GAS

	SAMPLE No. 1			SAMPLE No. 2		
	First Run	Second Run	Deviation	First Run	Second Run	Deviation
CH_4	86.39	86.45	0.06	86.70	86.81	0.11
C_2H_6	9.00	8.93	0.07	8.83	8.75	0.08
C_3H_8	3.26	3.29	0.03	3.14	3.12	0.02
C_4H_{10}	1.24	1.23	0.01	1.21	1.20	0.01
C_5H_{12}	0.11	0.10	0.01	0.12	0.12	0.00
	100.00	100.00	Av. 0.036	100.00	100.00	Av. 0.024

COMMERCIAL BUTANE

	SAMPLE No. 3			SAMPLE No. 4		
	First Run	Second Run	Deviation	First Run	Second Run	Deviation
C_3H_8	4.69	4.73	0.04	4.34	4.41	0.07
$I\text{-}C_4H_{10}$	22.17	21.48	0.69	20.76	21.14	0.38
$N\text{-}C_4H_{10}$	71.11	71.64	0.53	72.84	72.43	0.41
C_5H_{12}	2.03	2.15	0.12	2.06	2.02	0.04
	100.00	100.00	Av. 0.34	100.00	100.00	Av. 0.22

heavier hydrocarbons cannot always be completely distilled from the column. The charcoal used in all of these, however, was full 40-minute activity. Preliminary experiments indicate that the retentivity of the charcoal can be reduced by the deposition of salt on capillary surface of the carbon so that hydrocarbons as heavy as decane can be quantitatively removed. The work on this phase of the problem is still in progress and it is too early to draw any final conclusions, but the results so far indicate that we will have no difficulty in handling mixtures containing hydrocarbons as heavy as decane. The highest boiling hydrocarbons which can at present be actually separated are pentane and hexane. Thus, hexane and heavier hydrocarbons will be determined as a single group.

Acknowledgment

The writer wishes to acknowledge the assistance of Lloyd V. Guild, of the Burrell Technical Supply Company, Pittsburgh, Pennsylvania, who has played an important part in the development of many details of the apparatus, particularly in connection with the volumeter and thermal conductivity cell.

Normal Butane

R. C. ALDEN, Phillips Petroleum Company

Before the Annual Meeting of the Natural Gasoline Association of America, Dallas, April 15, 1943

AT THIS time, with isobutane so much in the forefront, some explanation should be given for choosing to discuss normal butane. With the advent of butane isomerization processes, isobutane and normal butane are becoming almost synonymous. If, as some seem to think, there is to be a shortage of isobutane, attention must then be focused on normal butane. It is further of significance to note that the tremendous refinery uses of C_4 hydrocarbons is bringing about a definite problem in motor-fuel volatility. Propane as a substitute for butane in motor fuel is under serious consideration in many places. All of these trends provide incentives for natural-gasoline manufacturers to increase C_4 extraction at natural-gasoline plants. Normal butane may become as important as isobutane has already become.

Referring to the processes for the manufacture of aviation gasoline from light hydrocarbons it is characteristic of them that a large portion of their investment and critical-material use is for the fractionation of the light hydrocarbons. The deisobutanizer or "butane splitter" is a substantial part of the investment in butane-isomerization plants, in alkylation plants and in codimer plants. Thus any natural-gasoline manufacturer who is seriously considering a "butane splitter" for the segregation of field isobutane should also study the amplification of his project to include at least butane isomerization and perhaps alkylate or codimer production.

To illustrate the point made in the preceding paragraph simplified flow diagrams of four process arrangements are shown in Figure 1. In each case, C_4 and lighter from natural gasoline is the entire feed to the system.

In these four diagrams each succeeding one is identical to its predecessor except for the addition of one or more operations. The sizes of the various units, of course, will depend on the successive operations.

In Figure 1 the solid flow lines represent the simple case of the segregation of isobutane from natural gasoline C_4's and lighter. Equipment requirements are a "butane splitter" and a depropanizer. The operation segregates the feed into three streams; isobutane, normal butane and propane and lighter.

The dashed flow lines in Figure 1 represent the flow diagram for the addition of a butane-isomerization unit to the system previously described. To the

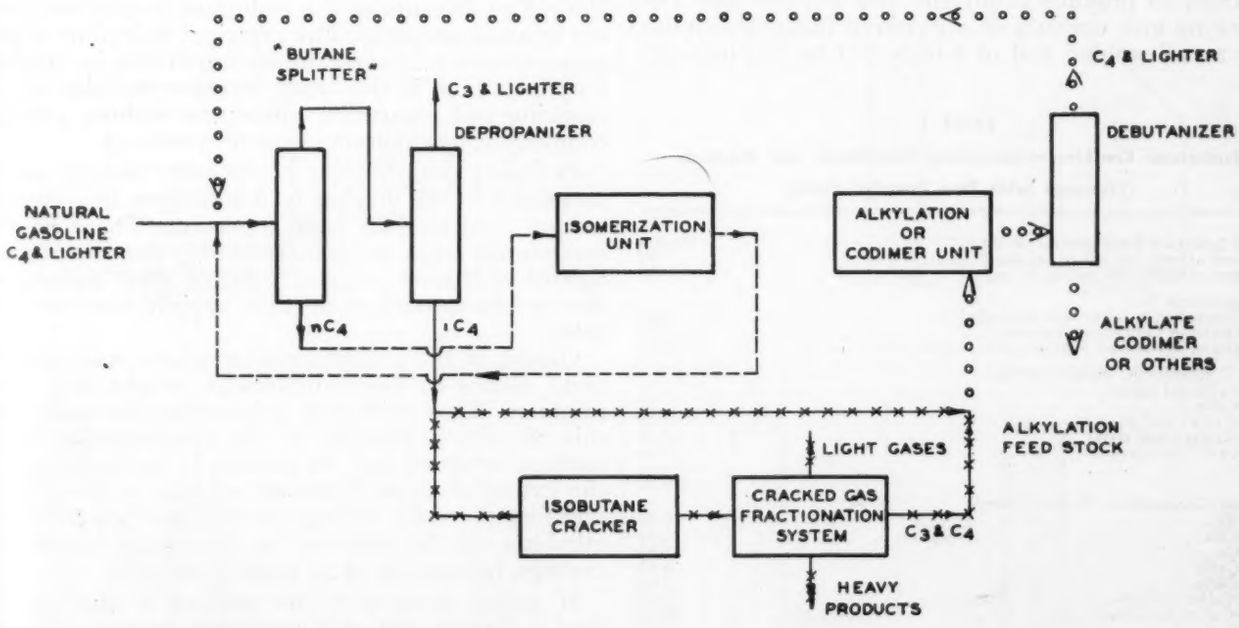


FIGURE 1

equipment has been added an isomerization unit to which is fed normal butane from the "butane splitter" and whose output is added to the feed of the "butane splitter." Obviously, the columns will have to be increased in size, but the fractionation steps are the same. In this operation two products are made, isobutane and propane and lighter.

It is a rare thing for an adequate olefin-bearing stream to be available to a field natural-gasoline situation. The crossed flow lines in Figure 1 represent the addition of an isobutane cracker to the equipment already provided. All or a portion of the isobutane from the depropanizer is fed to the isobutane cracker. In the cracker the isobutane is cracked to a depth of 20 to 30 per cent. The C_3-C_4 content of the cracked gas is ideal for feed to a codimer plant or mixed with uncracked isobutane is ideal feed for an alkylation unit. In the event neither of these units is installed the product should be of interest to refiners with alkylation or codimer facilities.

As a final step, the circle lines in Figure 1 show flow for the addition of an alkylation or codimer unit. In the case of a codimer unit all the isobutane from the depropanizer would be charged to the isobutane cracker. In the case of an alkylation unit only a portion goes to the isobutane cracker. The effluent of the conversion unit passes to a debutanizer whose kettle product is the alkylate or codimer. The overhead C_4's and lighter is fed to the "butane splitter" (or to the depropanizer or to the conversion unit feed or to any combination of these three).

Of particular interest in this sequence of flow diagrams is that portion of Figure 1 which shows the isobutane cracker, since this provides an olefin-bearing stream for subsequent conversion operations. The flow diagram for this operation together with the flow for the codimer plant is shown in somewhat greater detail in Figure 2, which is self-explanatory.

Phillips Petroleum Company has had in operation for five years a plant in which isobutane is thermally cracked to produce propylene and isobutylene. The cracking unit consists of a gas-fired furnace containing an all-welded coil of 4-inch OD by 3½-inch ID 18-8 chrome nickel alloy tubing having an aggregate length of 2511 feet.

TABLE 1

Isobutane Cracking—Operating Conditions and Products

(Furnace with Two Parallel Coils)

Total Isobutane Feed (gallons per day)	123,000
Pressure at inlet (lb. per sq. in. gage)	97
Pressure at outlet (lb. per sq. in. gage)	26
Temperatures °F.:	
Furnace inlet (after heat exchange)	600
Outlet of Convection Sections	890
Outlet of Radiant Sections	1,350
Feed Compositions, Weight percent:	
C_3H_8 and lighter	1.11
C_3H_6	1.33
iC_4H_8 (+nC_4H_8)	1.28
iC_4H_{10} (+nC_4H_{10})	95.74
C_5+	0.54
	100.00
Product Composition, Weight Percent:	
H_2	0.40
CH_4	4.64
C_2	0.95
C_3H_8	8.57
C_3H_6	1.83
iC_4H_8(+nC_4H_8)	13.83
iC_4H_{10}(+nC_4H_{10})	68.61
C_5+	1.17
	100.00
Percent Isobutane Cracked Per Pass	28
Ultimate Yields:	
Pounds iC_4H_8 per 100 pounds C_4 feed	49
Pounds C_3H_6 (net) per 100 pounds C_4 feed	26
Total Useful Products per 100 pounds C_4 feed	75

Operating temperatures have been in the range 1200°F to 1350°F; usual flow rates have been from 75,000 to 125,000 gallons of isobutane per day; and pressures have been in the range 60 to 80 pounds per square inch, gauge.

Conversion of isobutane per pass through the cracking coil has been approximately 25 percent. Ultimate yield of isobutylene per 100 pounds of isobutane destroyed has been about 50 pounds. In addition about 25 pounds of propylene have been obtained, making the total yield of useful olefins 75 pounds per 100 pounds of isobutane cracked. A considerable quantity of hydrogen is also produced.

The isobutane cracker is simple in design and operation, and requires a relatively small amount of critical materials for its construction.

For most efficient operation, the isobutane used for olefin production should be pure. However, the presence of normal butane and lighter hydrocarbons in an aggregate amount of the order of 10 percent or less will not seriously affect the cracking operation.

Normal butane is the hydrocarbon most likely to occur as an impurity. Since normal butane is somewhat less stable than isobutane, it is decomposed to a greater extent than is isobutane in a given time at a fixed temperature. The decomposition products of normal butane are principally hydrogen, methane, ethylene and propylene. Only about 12 percent of the normal butane cracked reacts to form normal butylenes. In most present applications, butylenes are more useful than propylene or ethylene. Consequently, normal butane should be kept at as low a concentration as possible.

Propane cracks to form principally propylene, ethylene, methane and hydrogen. It is much less reactive than the butanes, and acts substantially as a diluent when present in small amounts in isobutane being cracked. Since ethane and methane are even less reactive than propane, they, also, may be considered as diluents of the isobutane if they are present in small amounts. The principal objection to propane, ethane and methane as impurities in cracker-feed isobutane is that they increase the size of the cracking and separation equipment without yielding compensating amounts of useful products.

Pentanes plus heavier compounds should not be permitted in the cracker-feed isobutane in a concentration greater than 1 or 2 percent. These heavier compounds crack much more readily than butane and lighter hydrocarbons, and some of their decomposition products tend to degrade rapidly into tars and coke.

Olefins in the cracker-feed isobutane will crack to yield olefins of lower molecular weight and other products. They will also polymerize thermally, but this reaction is affected by the concentration of the olefin. Butylenes may be present in the isobutane to the extent of about 2 percent without noticeably increasing the coke and tar formation. Propylene and ethylene can be tolerated in somewhat larger percentage because of their greater stability.

If sulfur compounds are present in the cracker-feed isobutane they will crack and undergo other reactions similar to those of hydrocarbons. Sulfur will consequently be found in the olefinic products. Since most applications of isobutylene and propylene require them to be substantially free of sulfur compounds, it will usually be found desirable to free iso-

butane of sulfur compounds before using it for cracking stock.

Table 1 shows typical feed and product compositions for the isobutane-cracker, when operating in conjunction with a polymerization (or codimer) unit. The composition of the product C_3 and C_4 is suitable for charging to a polymerization (or codimer) unit as shown in Figure 1 and in some detail in Figure 2. With uncracked isobutane added the product C_3 and C_4 is ideal as a feed stock to an alkylation unit as shown in Figure 1.

It is of importance to consider the post-war possibilities of going the extreme route on the flow diagram shown in Figure 1 where isomerization, isobutane cracking and alkylation are put into practice, assuming that butanes extraction has been raised to well above 90 percent and all the butanes are processed to produce alkylate. Under these circumstances it is estimated that the blend of butane-free natural gasoline and alkylate would have a Reid vapor pressure well under 10 pounds and an ASTM octane number unleaded of about 80. If in the course of developing the full wartime potential of the situation, facilities were installed for the segregation of normal and isopentane, means would be at hand for controlling vapor pressure and anti-knock characteristics over a considerable range. It is therefore evident that these newer operations provide a means either now or in the future for the natural-gasoline manufacturer to become a motor-fuel manufacturer.

There are, of course, many other process possibilities for the natural-gasoline hydro-carbons. The writer has presented the most simple ones partly to simplify the matter but more importantly because the things here discussed are almost entirely covered in pre-Pearl Harbor literature and in issued patents. Nevertheless, the comparatively simple processes described here serve to illustrate the new importance of normal butane.

It should be stated that there is not an easy road to the wartime installation of such process steps in natural-gasoline situations. Of paramount importance to the war effort is the accomplishment of the necessary results with the minimum expenditure of critical materials, transportation, time and manpower. Basically the problem is to find adequate supplies of isobutane and olefins to manufacture the required quantities of alkylates. Olefins often can be made in increased quantities by revising refinery operations. Normal butane for isomerization is abundantly available at refineries. Where conversion facilities already exist there are many possibilities of raising production by the elimination of bottlenecks. All of these things must be taken into account before "ground-up" proposals can receive serious consideration.

On the other hand, the writer has seen each successive estimate of the requirements for aviation gasoline higher than its predecessor. There has been no recession. It is probable that as long as the war lasts the requirements will continue to increase. To be forehanded, natural-gasoline manufacturers should be developing projects for consideration by government agencies. In the meantime no greater service to the war effort can be performed than to take every step to increase deliveries of normal butane and isobutane as relatively pure materials or as mixed butanes or in natural gasoline to refineries that have facilities for converting these materials to 100-octane gasoline or to synthetic rubber.

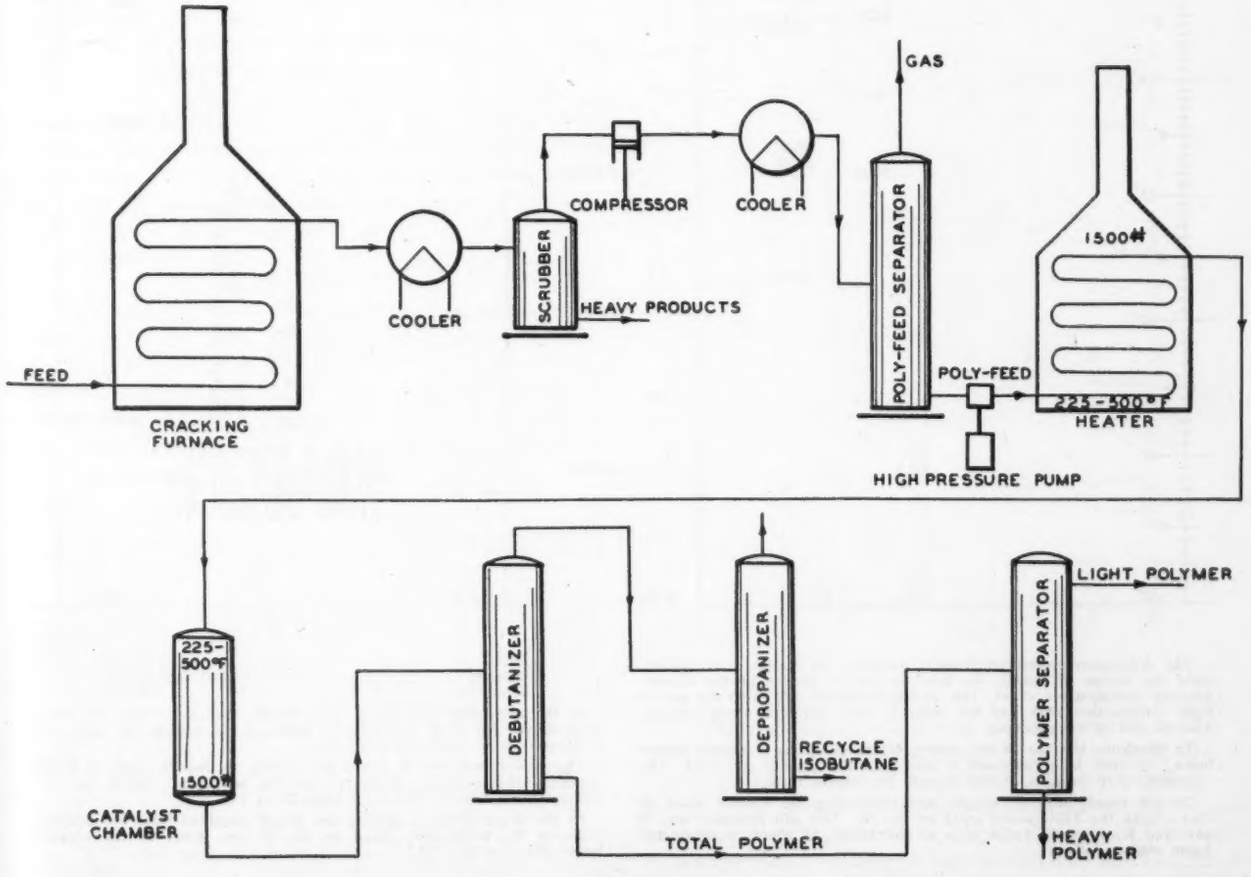
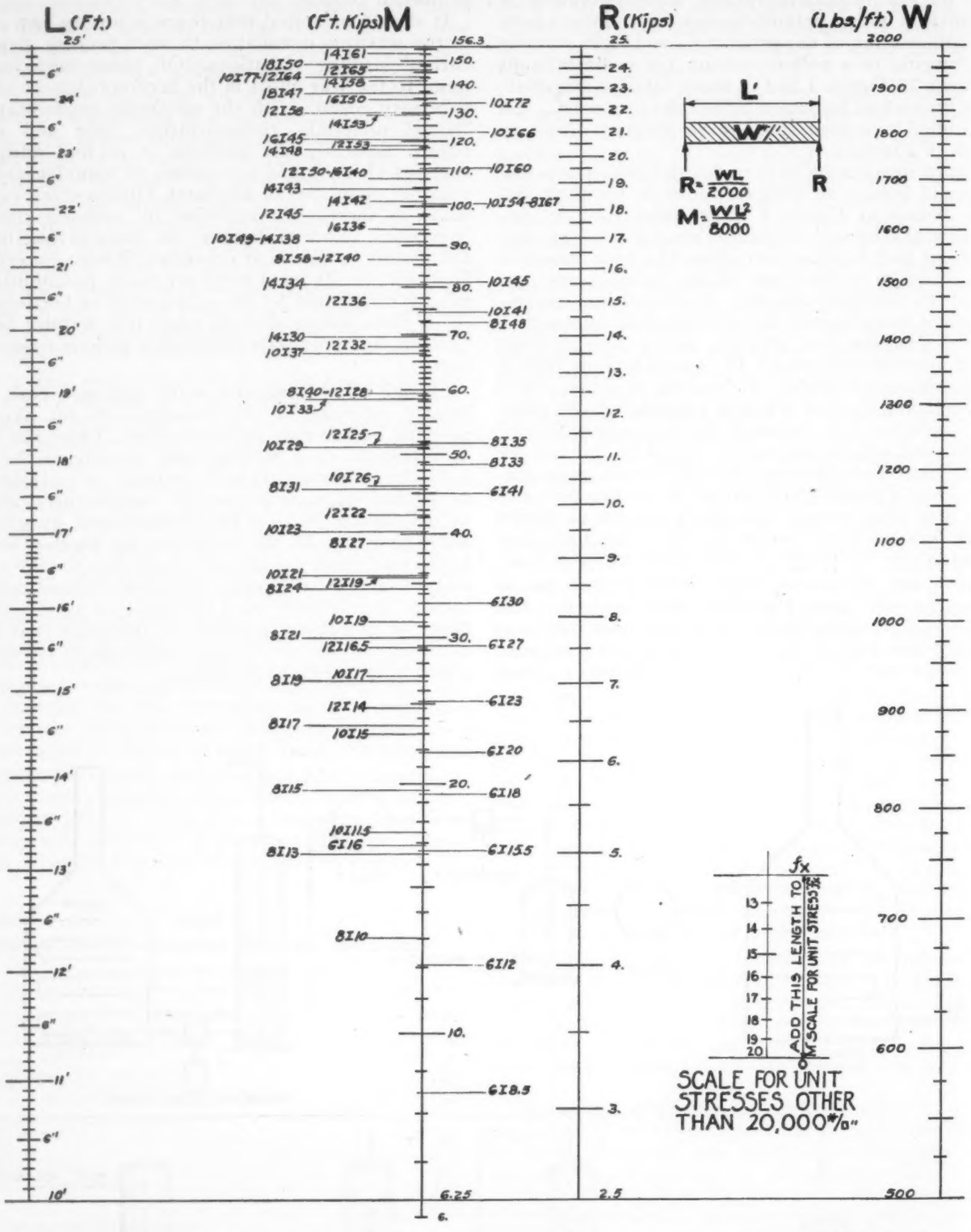


FIGURE 2

A Nomographic Chart for the Design of Floor Beams



The draftsman sometimes finds it necessary to design or to investigate the design of beams. He may do this by means of the accompanying nomographic chart. The author designed this chart for use in light construction work and has found it very useful for rapid calculation as well as for checking.

To illustrate the use of this chart, let us design a uniformly loaded beam, 19 feet long, carrying a load of 1300 pounds per foot. The allowable unit stress is 20,000 pounds per square inch.

On the chart, draw a straight line connecting the 19-foot point on line L with the 1300-pound point on line W. This will intersect line M and line R at points which give us the values of shear, moment and beam size as follows:

Shear	12,300 pounds
Moment	52,800 foot-pounds
Beam	12 I 28

If the allowable unit stress were 15,000 pounds instead of 20,000 used above, the shear and moment values would remain the same, but a heavier beam would be required.

The new beam size is found by adding to the M scale a length equal to the distance, measured on the auixiliary "Scale for unit stresses other than 20,000 psi," from 20 to 15.

In the above problem, adding the length obtained from the auxiliary scale to the point first found on the M line, gives us the required beam size — a *14 I 34*.

Gas Analysis by Means of the Mass Spectrometer

O. L. ROBERTS, The Atlantic Refining Company

Before the annual meeting of the Natural Gasoline Association of America, Dallas, April 14, 1943

IN THE early stages of the natural-gasoline industry the charcoal and the compression tests were sufficient for arriving at the value of casinghead gas and also for determining the general design of gasoline plants. As time went on it was recognized that more information relative to the composition of the gas was required; particularly when special narrow-boiling fractions were to be made. In the future the refining industry will no doubt require that the natural-gasoline manufacturer know still more about what his product contains.

A resume of the efforts to develop analytical techniques will not be presented but it will suffice to say that there is need for better techniques. It is the purpose of this paper to discuss the application of the mass spectrometer to the analysis of both gas and liquid hydrocarbons. The discussion will consist of:

A. General principles of operation of the instrument.

B. What the instrument must do to make quantitative analyses possible.

C. Several examples of mixtures which have been analyzed by the mass spectrometer.

Time will not permit a discussion of the details of the electrical circuits, the analyzer tube, the recording system, the gas-inlet system, and the methods of computations. Furthermore, the disclosure of these details can be made only in accordance with the secrecy orders which surround them.

Principles

It is familiar fact that the path of an electric current is surrounded by a magnetic field which is created by the current itself and that the path of the current will be deflected if this magnetic field is acted upon by another magnetic field. It is also a familiar fact that an electric current consists of an electric charge or charges in motion. If each of the molecules of a mixture of gases is electrically charged with a single positive charge and if each of these charged molecules are set in motion by virtue of the attraction of a nearby negatively charged body, then these moving, positively charged molecules or positive ions constitute an electric current. If these positive ions are made to traverse a path through a magnetic field of uniform strength then each ion will be deflected and the amount of the deflection will be a function of the mass of the molecule. By this means a stream of molecules of different masses can be separated according to their mass.

The reason why these ions of different masses will be deflected by different amounts is as follows. Since it was assumed that each ion was charged with a single positive charge, and since all of the ions are being attracted by the same negatively charged body,

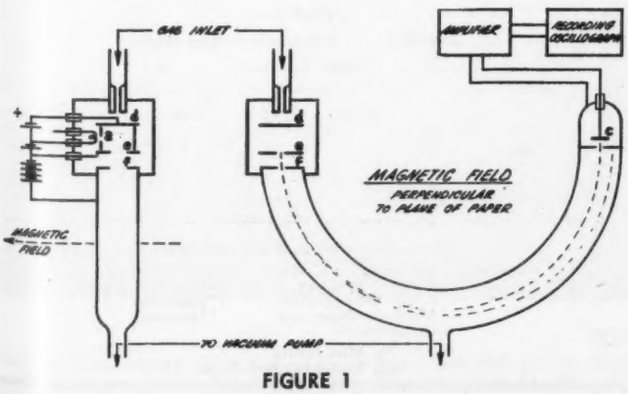


FIGURE 1

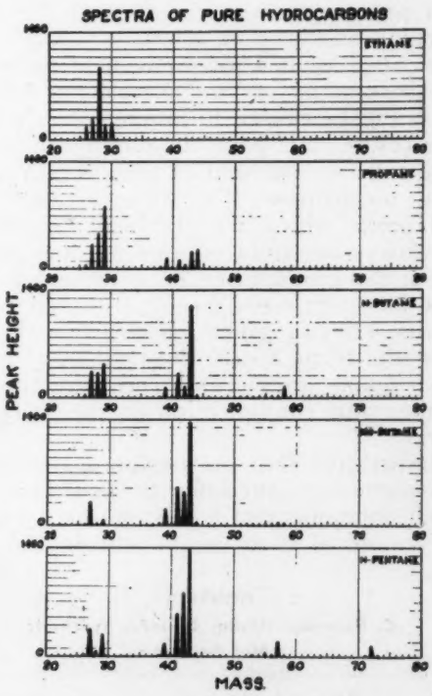


FIGURE 2

the velocity which each ion acquires at the end of a given period will depend upon the mass of the ion. The lighter ions will acquire a higher velocity than the heavier ions. Since these ions in motion constitute an electrical current, the higher speed or lighter ions represent stronger currents than do the heavier ions. Consequently, since the strength of the induced

FIGURE 3
C_1 — C_4 Paraffin, Olefin Synthetic
Mol Percent

	Manometer	M.S.
Methane	11.3	10.9
Ethylene	1.5	1.7
Ethane	22.1	21.4
Propene	11.9	11.8
Propane	31.1	31.0
Iso-butane	5.0	5.0
Iso-butene	4.4	4.7
Butene-1	5.0	6.2
Butene-2	0.7	0
n-Butane	7.0	7.3

	Complete Analysis	Normal, Isobutane, Total Butenes
Man Hours	3¼	¾
Elapsed Time	2 Hrs. 50 Mins.	¾

magnetic field increases as a function of the strength of the current the magnetic field surrounding the high speed or lighter ions is greater than in the case of the heavier molecules. The interaction forces between the externally applied magnetic field and the magnetic field surrounding each ion in motion is therefore greater in the case of the lighter ions and they will be deflected to a greater extent than will be the heavier.

Figure 1 is a schematic drawing of a mass spectrometer. The gas of unknown composition is admitted into chamber (a). A small fraction of the gas is given a positive charge due to bombardment by electrons which are liberated from a heated filament. The energy of the bombarding electrons is high enough to break some of the molecules into fragments which are also positively charged. The positively charged ions are accelerated toward the electrodes (e) and (f) and after passing through these electrodes enter the semi-circular analyzer tube with a high velocity. The externally applied magnetic field deflects these positive ions and by varying the electric field ions of each mass can be caused to impinge on the collector electrode (c). At this point the number of ions which reach the collector per unit of time is measured by a recording mechanism. The record produced is a series of peaks which are graphical representations of the relative amounts of ions of each mass. The analysis of the mixture can be determined if the instrument has previously been calibrated with pure compounds. For any given hydrocarbon the particular fragments formed, and the ratio of the amounts of the particular fragments formed are functions of the number and configuration of the atoms in the molecule.

It is imperative that the design and construction of the instrument be such that the spectrum obtained from each component of a mixture be a function of the percentage of each component in the mixture.

FIGURE 4
C_4 Paraffin, Olefin, Diolefin Synthetic
Mol Percent

	Manom.	M.S.	Manom.	M.S.	Manom.	M.S.
Propene	0.9	0.4	0	0	0	0
Butadiene	66.6	67.2	92.6	92.5	3.8	3.8
Isobutane	0	0.6	0	0	0	0
Isobutene	0.9	1.0	0	+0.2	30.4	28.9
Butene-1	7.1	8.1	1.9	2.0	31.4	29.2
Butene-2	6.9	5.5	5.5	5.3	34.4	38.1
n-Butane	17.6	17.2	0	0	0	0

	Complete Analysis	Butadiene Only
Man Hours	3¼	35 Minutes
Elapsed Time	2 Hrs. 50 Mins.	35 Minutes

FIGURE 5
C_5 and C_6 Paraffins, Cyclics and Aromatics
Mol Percent

HYDROCARBON	Fractionation (100 Plate) Column	Ultra-Violet Absorption	Mass Spectrometer
Pentanes	3.8	....	3.7
2-2 Dimethylbutane	14.0	....	15.0
Cyclopentane	1.6	....	2.0
2-3 Dimethylbutane	9.4	....	7.7
2-Methylpentane	33.0	....	32.2
3-Methylpentane	13.9	....	14.6
n-Hexane	12.8	....	13.5
Methylcyclopentane	8.7	....	9.3
Benzene	2.9	2.0	2.1

10 Man Hours
9 Hours Elapsed Time

That is to say, the spectrum obtained from the gas mixture must be truly a summation of the spectra of each component making up the mixture. If X components are present in a mixture the composite mixture spectrum should be identical with that obtained by multiplying each peak in the spectrum of each component by its mol fraction and adding the resulting products for each peak. If the construction of the instrument does not permit obtaining such a composite additive spectrum analysis is impossible.

Figure 2 shows the mass spectrums of several pure hydrocarbons. The abscissas represent the mass and the ordinates represent amounts of each mass. It will be observed that in the case of normal and isobutane, fragments with the same mass are present but the proportions of the fragments vary sufficiently to make analysis possible. Differences of this sort enable isomers of the various hydrocarbons to be determined.

Since the record produced by the instrument for a gas mixture is a summation of all of the individual components present in the mixture, if the spectrum for a pure hydrocarbon is known its contribution to the composite gas mixture spectrum can be determined. Interpretation of the composite gas mixture spectrum involves separating the individual contributions made by each of the components and determining the amount of these contributions. The interpretation of spectrums obtained from mixtures containing light hydrocarbons is relatively simple and the complexity of the interpretation increases as the molecular weight of the hydrocarbons increase. At present the mass spectrometer has analyzed mixtures containing C_8 hydrocarbons although not all of the C_6, C_7 and C_8 hydrocarbons have been determined. Before this can be done pure hydrocarbons must be obtained for calibration purposes. A 10-component mixture containing methane, ethane, ethylene, propane, propylene, normal-butane, iso-butane, iso-buty-

FIGURE 6
Gasoline + Aromatics—Synthetic
Mol Percent

	Synthetic	M.S	Synthetic	M.S.
Non-aromatics	49.1	49.1	52.9	55.0
Benzene	12.7	12.5	5.7	5.7
Toluene	37.9	38.4	21.0	21.8
Xylene	....	....	20.3	17.5

Non-aromatics in above mixtures

n-Hexane	n-Heptane
2-Methylpentane	Methylcyclohexane
2, 3-Dimethylbutane	"Isooctane"
Methylcyclopentane	"Isooctene"
Cyclohexane	

2¾ Man Hours
2¾ Hours Elapsed Time

lene, butene-1 and butene-2 requires less effort in interpretation than would a mixture of 5 isomeric C_6 hydrocarbons. The difference in ease of computation lies in the fact that in the first mixture many of the components can be determined separately, whereas in the latter mixture the determination of the composition of the mixture requires the solution of 5 simultaneous equations. In general, an experienced operator and computer who is confronted with making gas analyses of all types would average about two hours per sample. This includes the time of running the instrument and computation as well as making check determination. Many samples containing hydrocarbons from C_1 to C_4 inclusive can be analyzed in about half an hour.

The actual quantity of gas needed for an analysis is less than one tenth of a cubic centimeter. This is ample for several check determinations.

Examples of Compounds and of Mixtures Which Have Been Analyzed by the Mass Spectrometer

The instrument has been calibrated for the C_1 to C_5 paraffins and olefins, C_6, C_7 and C_8 normal paraffins and several of the isomers of each of these hydrocarbons. Calibration patterns have also been obtained for hydrocarbons such as butadiene, some of the acetylenes, benzene, toluene, the xylenes, and some of the cyclic hydrocarbons typified by cyclopentane and methylcyclopentane. In addition, carbon dioxide, hydrogen sulphide, nitrogen, oxygen and hydrogen have been studied.

Figures 3, 4, 5 and 6 shows samples of what can be done with the mass spectrometer. The number of analyses that have been made to date by the mass spectrometer runs into the hundreds and an instrument has been operated continuously for a 4-month period. During the period of continuous operation 15 to 20 runs a day were made. The runs were made during the 8-hour day shift but in order to stimulate 24-hour operation all the voltages were left on during the 4-month period.

Figure 7 shows the external appearance of the first commercial mass spectrometer which is designed for and is capable of making quantitative gas and liquid analyses. The instrument is automatic as regards the control of the currents and voltages, the making of the record and the control of the vacuum in the analyzer tube. The cabinet at the left contains the gas inlet and vacuum control systems, the analyzer tube and magnet are in the center. The large cabinet at the right contains the power supply, current and voltage tabilizers, the spectrum recorder and various controls. This equipment is now in use by The Atlantic Refining Company at Philadelphia.

Acknowledgments

Figures 1 to 6 inclusive were secured from the Consolidated Engineering Corporation of Pasadena, California. The information relative to continuous operation was also obtained from this source.

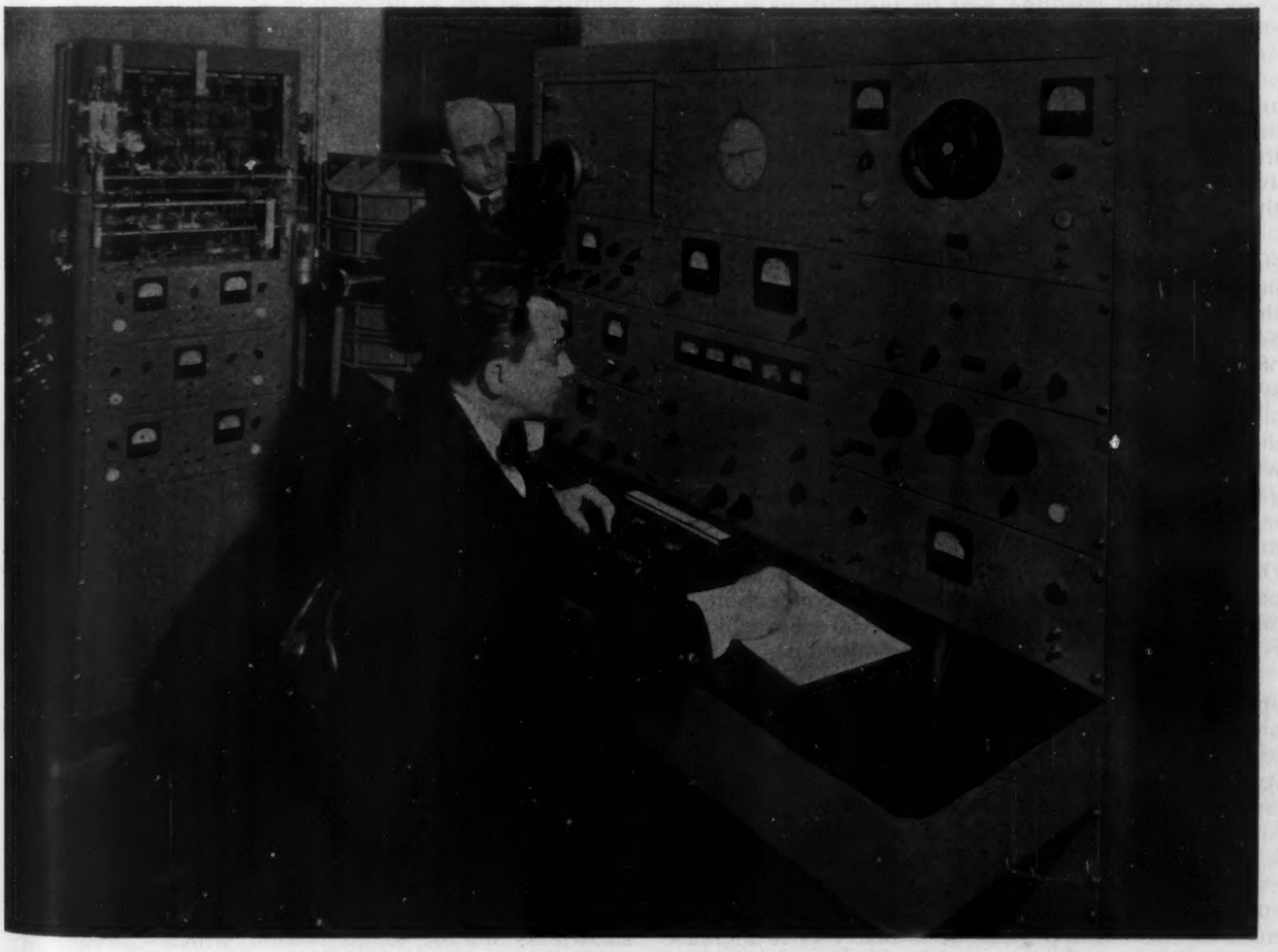


FIGURE 7

The mass spectrometer in action is shown being operated at the Philadelphia plant of The Atlantic Refining Company. Seated at the panel board is Dr. O. L. Roberts, author; standing, H. F. Wiley, Consolidated Engineering Corporation.

Role of Natural Gasoline Industry In the 100-Octane Gasoline Program

BRUCE K. BROWN

Assistant Deputy Petroleum Administrator, Petroleum Administration for War

Before the annual meeting of the Natural Gasoline Association of America, Dallas, April 15, 1943

FROM time to time I have been asked to define the scope of activity which the natural-gas and natural-gasoline industry should pursue in support of the national program to increase the production of 100-octane-aviation gasoline. The paper which I am presenting today is not a comprehensive answer to such a question, but I hope that it will provoke interest and support for a further contribution by your industry to certain specific materials vitally needed in this program.

It has been evident during the past months and is becoming increasingly so that production of fighting-grade-aviation gasoline will be insufficient to meet entirely the growing demands of our armed forces unless we redouble our efforts to insure maximum production of all materials and components which are necessary or can be incorporated advantageously into our fuel-production program. It is unnecessary to emphasize to you the importance of fighting-grade-aviation gasoline for the successful prosecution of the war.

Fighting-grade-aviation gasoline is made today by combining in suitable proportions synthetic or highly purified natural components which are selected for their desirable individual properties. Production of aviation gasoline today is limited by the availability of components of suitable quality, particularly the synthetic paraffinic type blending agents known as alkylate, hydrocodimer, et cetera, and aromatic blending agents such as xylene and cumene. Isopentane, which is produced in large volumes by the natural-gasoline industry, is another critical component, the increase in production of which would augment our much needed supplies of fighting-grade-aviation fuel. Of these critical components the two which are of particular interest to us in the present connection are alkylate, or the important raw material from which it is made; namely, isobutane, and isopentane.

Aviation-grade alkylate is the term which has been applied to the product obtained by a combination of olefinic refinery gases with isobutane in the presence of a catalyst. The limitation to our production capacity of this material at present is the availability of isobutane. One barrel of increased production of isobutane can be made ultimately into the equivalent of four barrels of additional 100-octane gasoline. It is evident, therefore, that perhaps the most important contribution to the 100-octane program which can be made by the natural-gasoline industry is to increase the production of isobutane both now and in the future.

You are all aware of the shortage of critical construction materials at the present time for the installation of new plants. These materials are needed not only for the construction of aviation-gasoline plants and rubber plants for components of synthetic rubber but also for the construction of airplanes, escort vessels, tanks, guns, and other highly essential equipment required for the successful prosecution of the war. It is therefore incumbent on each and every one of us to insure minimum use of critical construction materials for any new plant construction while at the same time accomplishing our important objectives. This is, of course, a challenge to the natural-gasoline industry so far as production of isobutane and isopentane are concerned, but I feel certain it can and will be met successfully through the efforts of the industry.

Two phases of the subject of isobutane and isopentane shall be stressed particularly by me here in this presentation; (1) the real and urgent need at the present time for increasing the production of isobutane and isopentane from natural sources employing maximum amount of used construction materials in obtaining such increase, and (2) a general technical description of the isomerization process employing normal butane for the production of isobutane.

With regard to maximum production from existing facilities, I should like to urge each of you to review your existing plant operations and to submit to the Natural-Gas and Gasoline Division of the Petroleum Administration for War proposals for increasing the production of isobutane and isopentane, with particular emphasis on the time required for conversion of existing facilities. I feel certain that sufficient outlet can be provided for the isobutane and isopentane so produced over an ample period of time to permit a reasonable return on any new capital invested and that there will be ample demand for the balance of the war for isobutane and isopentane of 95 percent purity or higher. We shall be pleased to discuss specific details with you as specific proposals are developed. We urge that all possibilities of increasing production this year be exhausted.

In addition to isobutane and isopentane, the natural-gasoline industry has available large supplies of normal butane which are currently used either for fuel or diverted into the motor-gasoline market. However, normal butane will also have an important place in the war program by a recently developed process known as butane isomerization which converts it into isobutane. If all available isobutane in this country were segregated from refinery gases and natural-gasoline-plant gases, there still would be insufficient

isobutane to meet the requirements for the aviation-fuel program. Isomerization of normal butane, however, is the key which unlocks the door to additional supplies and considerable experience has already been gained in the operation of several plants as an integral part of the aviation-fuel program. The government has included a considerable number of butane-isomerization plants. About 10 of the plants were scheduled to be in operation as of April 1, 1943, and 22 more by the end of this year. The total design capacity of these 32 plants is 25,500 barrels of isobutane per calendar day, or an average size plant of about 800 barrels per calendar day. The smallest plant has a design capacity of 68 barrels per day with several below 200 barrels per day. The largest plant is rated at 2,850 barrels per day.

The principal operating difficulty encountered to date has been corrosion because of the nature of the catalyst, but this and other minor problems are being rapidly solved.

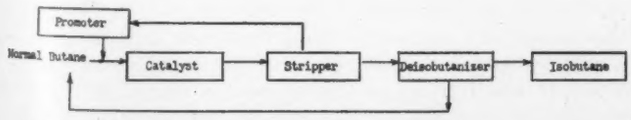
In several cases plant production is exceeding design capacity, e.g., one plant designed to produce 500 barrels of isobutane per day, because of the difficulty referred to produced only 200-300 barrels per day during initial operation. However, after minor changes had been made, design production was reached and then considerably surpassed. Recently this plant produced as high as 1,100 barrels per day, and the operator expects it to average about 900 barrels per day.

No definite figures are available for critical material requirements, largely because of the varying engineering standards in vogue and also because design capacity has not been clearly established as yet in all cases. The critical material requirements in any circumstances appears to be modest. It should be of particular interest to natural-gasoline-plant operators that a considerable portion of a butane-isomerization plant are the fractionating facilities. Thus, if a butane "splitter" is under consideration or can be justified for any reason enlargement of the project to include normal-butane isomerization should also be considered.

A number of butane-isomerization processes or variations of the same have been incorporated in the government's aviation-gasoline program. The following is an alphabetical list of those concerns that are actively developing, and licensing butane isomerization processes:

1. M. W. Kellogg Company
2. Phillips Petroleum Company
3. Shell Development Company
4. Shell Oil Company
5. Standard Oil Company of California
6. Standard Oil Development Company
7. The Texas Company
8. Universal Oil Products Company

The processes can be placed in two or possibly three rough classifications. A highly schematic flow diagram of a typical isomerization process is shown below:



Referring to the sketch, normal butane is passed through a chamber containing the catalyst. A carefully controlled amount of promoter is added to the butane. The isomerization reaction takes place under relatively mild conditions of temperature and pressure, and the product from the catalyst chamber consists practically entirely of isobutane, unreacted normal butane, and the promoter. The butanes containing the promoter are passed through a stripper which removes the promoter. The latter is then recycled to the catalyst chamber and the butanes are passed to a fractionation column where the normal and isobutanes are separated. The normal butane is recycled to the catalyst chambers, and the isobutane goes to product storage.

In typical butane isomerization operations the per pass conversion is 40-50 percent with an ultimate yield of isobutane of 90 percent or over, based on the normal butane in the feed.

The charge stock for an isomerization unit should consist of relatively pure normal butane. However, the presence of propane or isobutane is not objectionable, although there is a limiting value on the olefin and pentane contents, primarily affecting catalyst life and the economy of the process.

Catalyst life in the neighborhood of 50 gallons of isobutane per pound of catalyst has been obtained, and in some cases this figure is considerably larger. The promoter consumption in most cases is small. Operating costs, exclusive of depreciation and royalty, are expected to be under 1 cent per gallon of isobutane produced.

In October of last year the Office of Petroleum Coordinator for War, now the Petroleum Administration for War, recognizing the importance of isobutane in the aviation-fuel program and that it was a relatively new process from the operating viewpoint, called a meeting of the designers and operators of butane isomerization plants. The purpose of this meeting was to insure and to speed up the development of butane-isomerization processes. The various companies involved responded to this invitation in a most generous manner and subsequently have been contributing their experience and development in butane isomerization to a central body, namely the Butane-Isomerization Subcommittee of the Aviation-Gasoline Advisory Committee. This subcommittee has the assignment of assembling and disseminating the available information on butane isomerization to all those participating in government-approved isomerization projects. As an example of its functioning each operator of a butane-isomerization plant submits monthly operating reports to the subcommittee, which in turn summarizes the several monthly reports, and transmits the summaries to all operators and designers of butane-isomerization plants. Thus, any experience gained in butane isomerization is made available to those who can make use of the information in speeding up and improving their operations, present or prospective, also from time to time it is planned to have group meetings of operators and designers of these installations to further facilitate obtaining the maximum in speed and efficiency. One such meeting was recently held in Houston.

There are definite indications now that the supply of isobutane may become critical in the coming months. The problem is receiving the most careful attention by the Petroleum Administration for War, the Aviation-Gasoline Advisory Committee, and other agencies. It is certain that it is highly desirable and necessary that natural-gasoline-plant operators should give early attention to the possibilities of augmenting the supplies of isobutane, keeping in mind as stated previously the paramount necessity of using the least possible amount of new critical materials.

It is important that renewed consideration be given to increased extraction and segregation of isobutane from natural gas. Also as this discussion has stressed the possibilities of butane isomerization in the field should be given immediate consideration. It should not be overlooked, of course, that the transportation aspects of this matter are of the utmost importance and, therefore, careful consideration must be given to pipe-line, tank-car, and other transportation requirements for any given project.

It became evident quite early in the aviation fuel program that the diversion of C_4 hydrocarbons at refineries to aviation-fuel manufacture would result in many instances in a pronounced sacrifice in quality of finished refinery motor fuel from the viewpoint of front and volatility. Now that it appears there will be a growing need for normal butane to be further diverted to aviation-fuel manufacture, it is definitely in order for natural-gasoline manufacturers to give more intensive study to the matter of reducing the vapor pressure of natural gasoline, wherever there is the possibility of diverting the normal butane thus released from aviation-gasoline manufacture.

In conclusion I wish to point out that the indications are that we will need thousands of barrels per day more of isobutane and substantial quantities of increased isopentane if our national aviation-fuel program is to keep pace with the requirements of the armed forces. This is particularly true of the remaining critical months of 1943. Every barrel of additional isobutane and isopentane which can be brought into production this year will mean that additional fighting aircraft may take to the air and hasten the defeat of the Axis forces.

Dent Remover Does Pipe Face Lifting

FROM the dismantled equipment around the maintenance yard of United Gas Pipe Line Company, Shreveport, workmen have fashioned a device which removes dents from damaged pipe. It is a portable gadget, operated by hydraulic power.

Essentially the instrument consists of a power cylinder, mounted on a shoe whose lower surface is curved to conform to the inside diameter of the pipe being conditioned. Inside this cylinder works a short plunger, packed to withstand high pressure. Into the socketed top of the plunger fits the dowel end of a forming head, the upper surface of which is formed to fit within the circle of the size pipe being worked over.

Around the body of the ram unit is a clamp, on one side of which a pipe collar has been welded. For work at the edge of a section of pipe, a short handle may be screwed into this collar, while for work far within a double joint the handle may be made up of 20 feet or more of pipe.

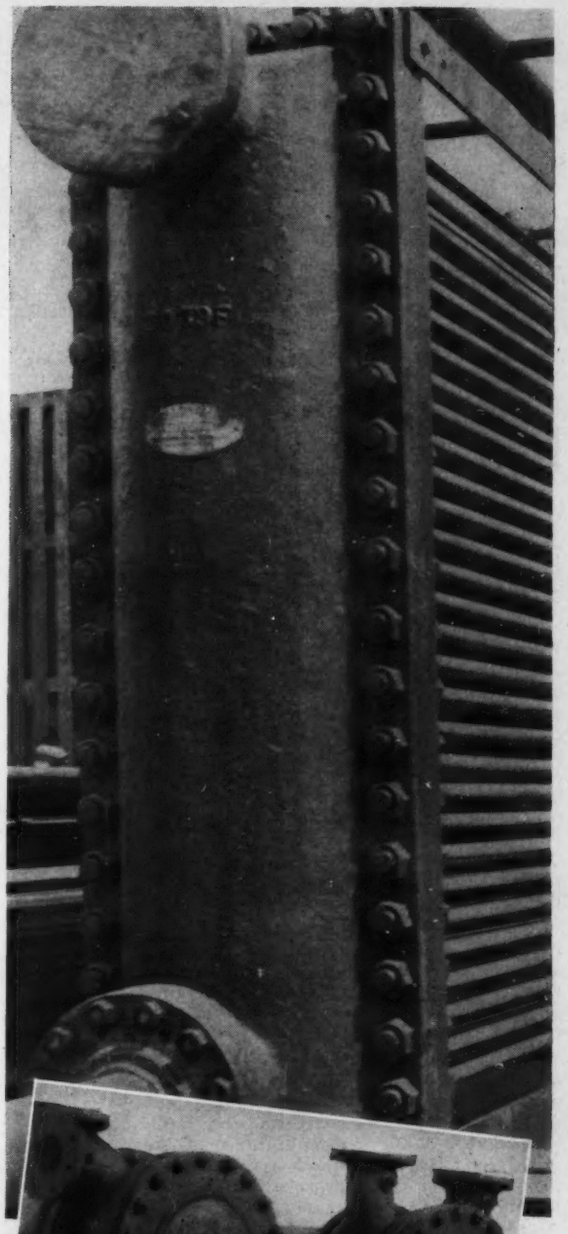
Pressure is applied to the ram through a pipe entering the base of the power cylinder, the pressure being generated through the medium of a high-pressure oil gun, such as is normally used for lubricating the fittings in the lubrication systems of trucks and heavy trailers. By using a heavy oil in this unit and applying pressure at the end of the normal lever furnished for grease-rack work, sufficient pressure is built up to force the ram out and remove even a heavy dent from pipe up to 0.37-inch in thickness. The unit is sturdy enough so that, if a dent prove hard to remove, pressure can be built up within the cylinder and the crushed or distorted pipe wall hammered on the outside, directly over the ram, and the metal thus aided in flowing back to shape before deformation.

To release the unit, after a pipe has been restored to former roundness, it is usually sufficient only to release the return valve at the pressure unit. If the ram does not readily reenter the cylinder with the release of pressure, the action can be accelerated by rocking the dedenter on the outer end of the bottom support, building up pressure enough against the lubricant against the plunger to cause it to reenter the pressure unit.

The unit is readily portable, and with short pipe sections forming the spotting handle, the entire unit may be dismantled and carried in a pick-up truck. Two men are normally used with the unit, one to do the spotting and watch the pipe, the second to operate the handle of the pressure unit; though the device is equally serviceable when worked by but one man, the affixing of a pedal to the pressure handle enabling the sole operator to spot the ram and build up pressure to hold it in place while he releases the pipe handle and takes over manual control of ram pressure.

PRACTICAL HELP

for users of non-ferrous refinery equipment



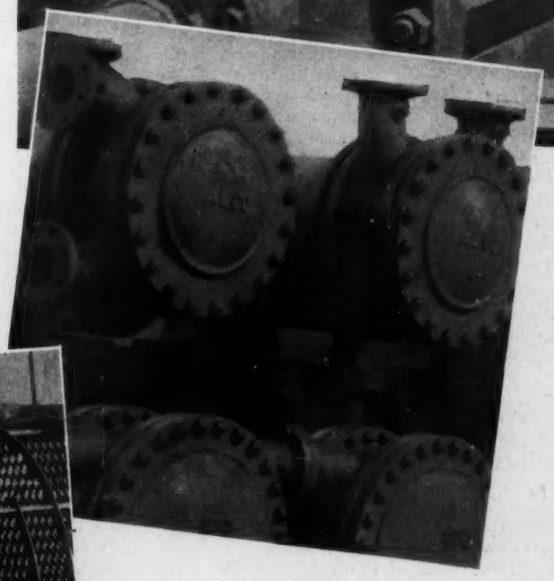
If you need non-ferrous condenser tubes and tube plates, and materials for use in fractionating columns, pressure vessels, heat exchanger shells, extractors, evaporators, stills, or similar equipment for war production—get in touch with Revere. For Revere understands many of the problems you are facing, and earnestly wishes to help. Through one or more of these four channels we may be able to do so:

Revere copper and copper-base alloys. Sound, superior metals produced in a range of compositions and forms meeting the special requirements of war processes.

Revere Bimetal. Where war requirements and service conditions demand, Revere can supply bonded Bimetal sheets and plate of S.A.E. 1010 carbon steel clad on one or both sides with copper as well as with certain other metals and alloys.

Welding technique. Practical assistance in welding which will aid in the completion of equipment *when* needed and insure uninterrupted service.

Revere Engineering Service. To help Revere customers in the selection of metals and in methods of fabrication so as to save time, increase output and reduce costs wherever possible.



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Intelligent Utilization of Our Natural Resources

RAY E. MILLER, Vice President, Hanlon-Buchanan, Inc.

Address as president of the Natural Gasoline Association of America, Dallas, April 15, 1943

IN MY address last year, I outlined the history of our industry in a facetious vein and dwelt on the fact that the Natural Gasoline Association of America had reached its majority. This year, as grown men of an industry supplying vital fractions for our country's war products, let's join forces in demanding more intelligent utilization of our available petroleum hydrocarbons. Let us visualize the petroleum industry as made up on the one hand of oil and gas wells with attendant natural-gasoline and cycling plants making available to the world markets a wide range of hydrocarbon mixtures from natural gas to heavy tars. As new fields are opened up, or as conservation equipment is developed, the relative percentages of individual hydrocarbons made available to this market changes from time to time.

Then, on the other extreme of our industry, is the market demand which also changes from time to time in the relative percentage of hydrocarbons which it has been educated or developed to absorb.

In between these extremes lies the opportunity of the research chemists and technologists, the refining and conversion operators, to find methods and operate conversion equipment which will take all raw products available and process them into fractions demanded by the developed market. This is true conservation and is possible either under a free economy or the national economy under which we are now operating, regardless of the terms you may use to describe it.

Under a free economy competition between, and price adjustments of, the various products guarantee their utilization. Under our present partially controlled economy, intelligent directives and recommendations, plus common sense in the aggregate of petroleum operations could guarantee the same end.

We see now, as we have seen many times in the past, a petroleum industry with too much of some fractions and too little of others and recurringly as those conditions have existed, false prophets have advocated destruction of the surplus fractions. Unfortunately for us in the natural gasoline and allied branches, we have too often seen that "Sword of Damocles" suspended above our heads. We have protested, but our voices were weak compared to the stentorian tones of such advocates. But, if conservation of petroleum has any merit whatever, why do we not hear more about utilization of what we have? Why should conversion equipment not be used to keep our available petroleum fractions in balance with market demands, rather than adding to the unbalance?

Good As Is

Would the intelligent lumberman spend time and money trying to convert soft woods to hard woods in order to use soft pine for flooring, when oak was available? Would a store cashier give dimes for pennies when pennies were scarce, or go to the bank for additional pennies? We have learned to make bricks without straw but I wonder when some of our refiner friends will learn that crude oil is not the only source of their refined products.

Someone has suggested that our future lies in a research program designed to convert our light ends into crude and heavy fuel oil, then by adding a little sulphur and other contamination, we would give joy to the refiner who could then reconvert them to approximately their original state. Please understand me—I do not indict the whole refining industry but only those highly vocal, misguided or malicious members who object to our existence.

Why do we have a natural gasoline branch of the petroleum industry? If all gas and light ends from an oil well would remain in solution with the oil until it is processed in the refinery, and if the condensable fractions in natural gas from gas wells were desirable fractions in gas fuel, all would be well. But casinghead gas and volatile fractions were for many years wasted at well mouth, separator or field storage tank, and gas utilities found it necessary to dry out natural gas to facilitate pipe-line transportation. This early wastage, constituting the equivalent of 5 to 10 percent of total oil production, challenged some ingenious conservationists some 35 years ago and our industry was born. No matter whether an individual plant is operated by the oil or gas producer or if such producers decided to deal with separate gasoline-plant owners large or small, the sum total of such plants make up the natural-gasoline industry and we who operate the plants are doing a commendable conservation job. I am proud of our industry.

For many years we have heard the cry of the conservationists that our stripper wells must be preserved in order to save and produce their underground reserves. I say to you that it is just as important to our petroleum economy that all hydrocarbons, once lifted above ground, be equally preserved.

I wonder if the advocates of natural-gasoline curtailment realize that they are recommending tremendous physical waste of light hydrocarbons? Gasoline-plant operators have no control whatever over oil allowables and such allowables combined with their regulated gas-oil ratios, determine the volume of gas delivered under contract by the producer to the plant. The plant operator has no choice but to process whatever gas is thus made available or to waste it after paying the producer's royalty. I know full well that many exceptions can be taken from that statement but, regardless of such quibbling, it is still true as a general statement.

We are hearing a lot about the necessity of additional wildcatting to discover new oil reserves for future demand while at the same time, and perhaps from some of the same voices, we hear recommendations that natural-gasoline and cycling-plant operations should be curtailed or shut down. When will our economic planners wake up to the fact that our conservation program is the equivalent of a lot of new wells and our production does, or can be converted to, replace or postpone those new wells?

Would anyone have the temerity to suggest that from every barrel of oil produced, the well owner must discard some two or three gallons after production, or that in every proven field every fifteenth or twentieth well must turn its allowable into the ocean? I proclaim that the man is shortsighted or criminally selfish who recommends any curtailment of our operations once the wells have been drilled that produce our raw feed. Again I say we are engaged in and should be commended for salvaging additional hydrocarbons which the well owners would otherwise waste. I am proud of our industry and apologize to no one. Our liquid products are useful, whether they be natural gasoline as a raw product, or specialties comprised of any closely fractionated cuts from that raw stream. They are useful in the war products need of the present and will again be useful in the peacetime products of the future.

Plenty of Distillate

I have stated that the relative percentages of various hydrocarbons available from all wells change from time to time. For the past few years, the discoveries of new fields have been preponderately of the light-oil and distillate type. Tremendous reserves have been proven and are now available for the drilling, yet the cry is going up to high heaven that we must have more wildcatting, more reserves of heavy crude production. Why? So that old-fashioned refiners can crack it into light products? If the old French queen were here now she might well say, "If they have no

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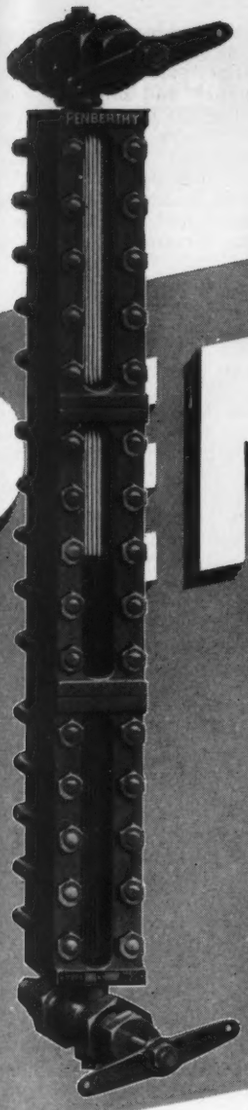

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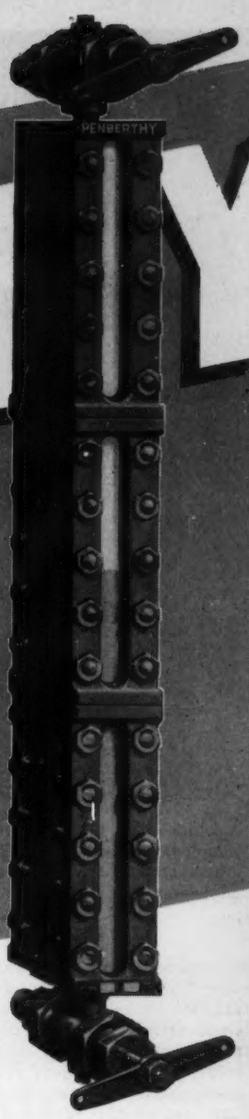

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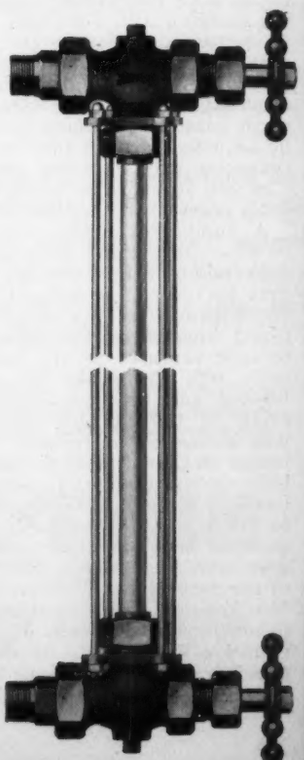

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PENBERTHY PRODUCTS

A watch from the membership was given to Ray E. Miller, who completed his second term as president of the Natural Gasoline Association of America. It was his second such gift from the organization, since he served as secretary before resigning to become vice president of Hanlon-Buchanan, Inc., and a watch was given him then. The presentation was made by T. R. Goebel, Shell Oil Company, Houston, also a past president of the association.

bread, let them eat cake," and the royal edict would be constructive, for the "cake" is available. May I quietly, and with due reverence, here and now say to the process engineer and to the refiner, "Why not design and operate your equipment to process readily available raw materials rather than demand, as some of you seem to do, that raw materials be discovered and made available to fit your prejudices?" The parade is not standing still. The "cake" eaters may be better nourished in the present era than those who demand bread. If the present trend of discovering lighter crudes as the drill goes deeper into the earth continues, refining processes must be adjusted to such raw stocks or new refineries will dominate your industry. Can you afford to be stubborn and wait for a reversal of the discovery trend?

A number of papers and discussions on this convention's program cover the conversion of our normal plant products to special products. I can neither recommend nor discourage the additional investment and effort necessary to such ventures. In the late 1850's and early 60's the snake oil market was flooded and new uses were found for crude oil. Early in this century, gasoline was discarded to furnish "oil for the lamps of China" until automobiles were built to consume it. In our own experience, a number of companies or operators who started primarily as natural-gasoline and distillate producers, but who were dissatisfied with the returns of the natural-gasoline market, ventured into the motor fuel, chemical and by-products fields. Such decisions must continue to be made by the individual operator. War dislocations and material shortages may make such decisions impossible now, but plans can be made tentatively now for post-war consideration.

The Natural-Gasoline Association of America should continue to sponsor and encourage research disclosing new uses, new processes and new products and make such information available to its members and the industry for their forward planning. Some of us may further engage ourselves in the field of chemicals; some in specialty cuts by close fractionation; some in conversion processes to compete in presently established large markets and some of us, I am quite sure, will continue to make natural gasoline. Many of our plants are small and are comparable to stripper-well oil producers, or to water-flooding, repressuring or other "secondary-recovery" producers. We are not only conserving natural resources, but conserving and liquidating a diminishing investment and no new capital expeditures are justified. We are salvaging what we can of a former investment.

As an industry, we have been repeatedly criticized for keeping our collective noses in our own business, especially when the market demand was dull and we were singing the old song, "Won't somebody buy our apples?"

Need for Equipment

No one has suggested that every oil producer should cease selling crude oil and get into the manufacturing end of the business. I doubt if there is room for Ellick Botts, the Consulting Pumper of Grayhorse, Oklahoma, and all the other stripper well operators to build refineries individually or collectively in an attempt to escape the danger of 10-cent oil of 1933 East Texas days. Incidentally, I seem to remember motor-fuel prices and demand reaching a point where the refiner paid part of the freight to the consumer and charged nothing for the gasoline, to get material out of storage. I also have seen large quantities of butane and propane burned at plants after it was produced and could find no market at any price. Adjoining pastures always look greener, but indigestion seems a common ailment in all walks of life.

Moreover, since the great majority of our products are going directly into war products or furnishing fuel for plants making war equipment, we are entitled to our share of available critical materials for repair and maintenance. A place must be reserved in the total supply picture for our total production. Conversion equipment must fit those products into the total demand for petroleum.

We require pressure equipment, tank cars and tank trucks for storing and transporting where pipe lines are not available to us, and such mobile transportation equipment is not interchangeable with that used for less volatile products. We are earnestly trying to transport our products by using the smallest number of trucks and tank cars necessary to reach the closest market where the best possible war use can be made of them. We have resisted suggstions that we ship to the East Coast for presumably inferior use when such shipments would greatly diminish production of aviation-gasoline on the Gulf Coast and at the same time require two or three times the number of tank cars for the longer haul.

In addition to direct conservation, our plants are delaying abandonment of many stripper wells and fields where the residue gas we return for fuel or repressuring, or the vacuum services, or even the small added revenue from gasoline sales means the difference between continued operation or abandonmnt.

Let's quit apologizing; let's quit the appearance of asking for favors; let's cast off the clothing of children and adolescents. We are grown up and must sieze our opportunities and accept our responsibilities. Let's get into the marching rhythm and go forward with the petroleum army.

What I am trying to say is, be careful, be prudent, but let's keep awake to future opportunities. We must always take some gambles or progress in commerce and civilization is lost. Let's overwhelm our present critics by intelligent ideas and useful products. Let's continue to help win this war and let's keep on believing in ourselves and convincing the world that our conservation efforts are directed in legitimate channels and furnishing legitimate products.

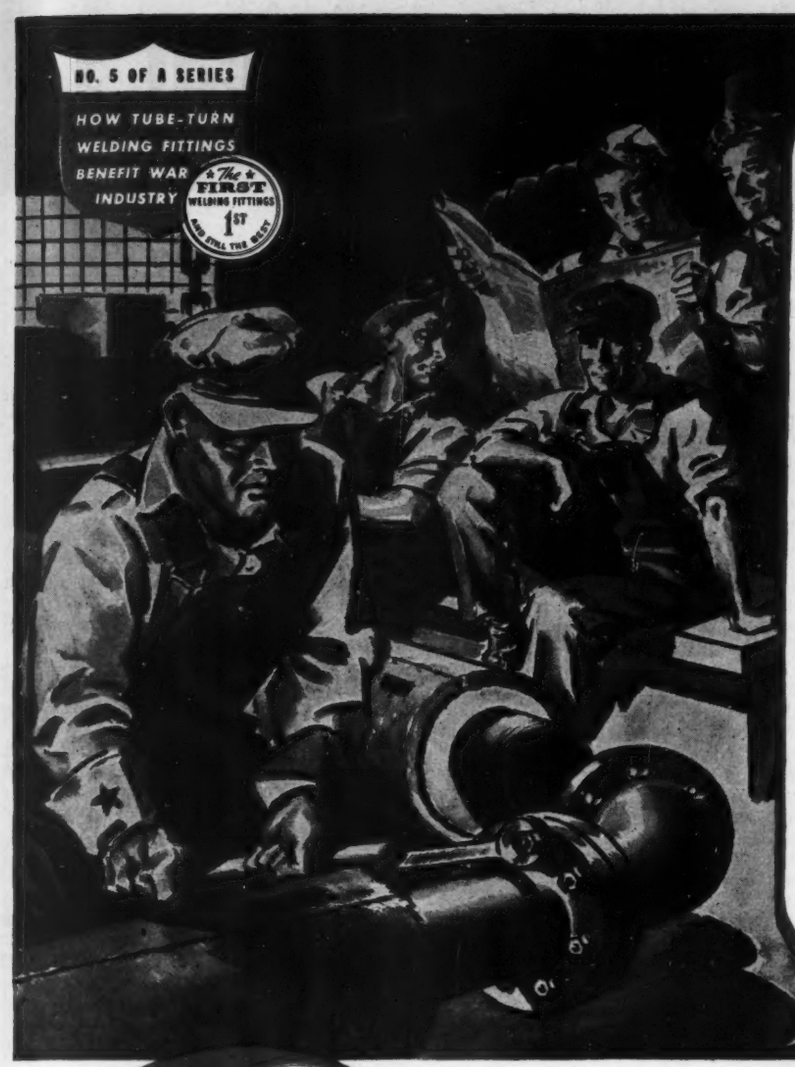
Gas Measurement Short Course Suspended

Southwestern Gas Measurement Short Course, regularly held each year at University of Oklahoma, Norman, to provide discussion of all phases of natural gas measurement and control, will not be held this year. The press of war effort and the current demands both for the facilities of the University and also the shortage of manpower in natural gas companies are factors instrumental in the decision. The 1944 Course is anticipated, although it, too, is contingent upon forthcoming circumstances.

NO. 5 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

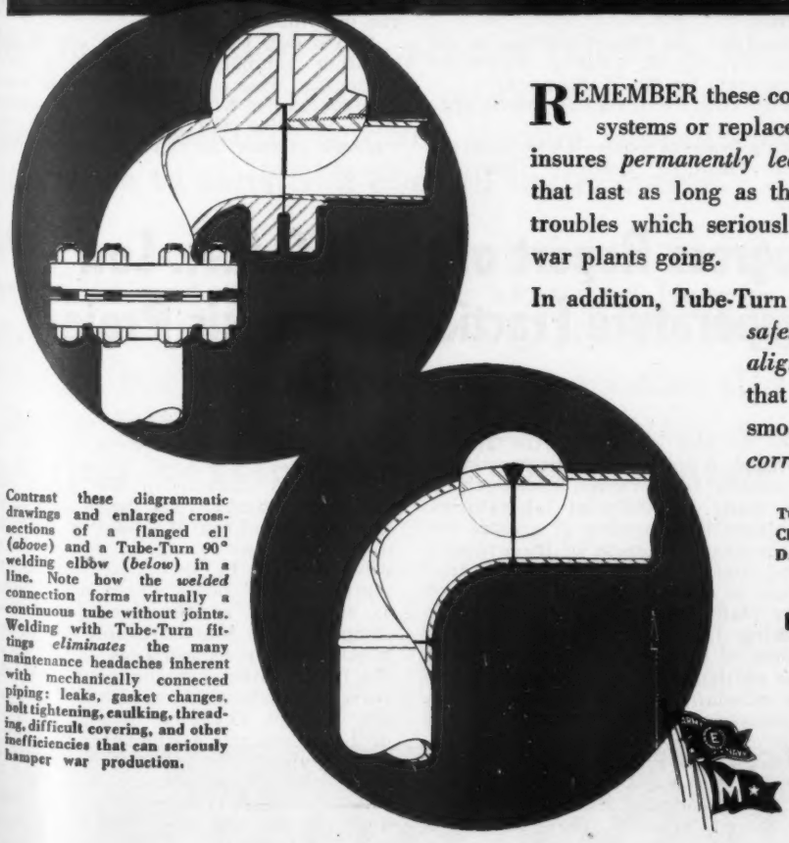
The FIRST WELDING FITTINGS 1ST AND STILL THE BEST



STOP

war production delays due to leaks and other avoidable piping troubles

WELD WITH TUBE-TURN WELDING FITTINGS



Contrast these diagrammatic drawings and enlarged cross-sections of a flanged ell (*above*) and a Tube-Turn 90° welding elbow (*below*) in a line. Note how the *welded* connection forms virtually a continuous tube without joints. Welding with Tube-Turn fittings *eliminates* the many maintenance headaches inherent with mechanically connected piping: leaks, gasket changes, bolt tightening, caulking, threading, difficult covering, and other inefficiencies that can seriously hamper war production.

REMEMBER these common-sense facts before you install new piping systems or replace old sections: welding with Tube-Turn fittings insures *permanently leakproof, trouble-free joints* and better fittings that last as long as the pipe itself. You banish many maintenance troubles which seriously interrupt the vital *piping arteries* that keep war plants going.

In addition, Tube-Turn welding fittings give you *greater strength and safety;* uniform wall thickness, for *easier, faster alignment and welding;* compact piping layouts that *save space, weight and installation time;* smooth inner walls that mean far *better flow, less corrosion* and *greater piping efficiency.*

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Report of the Technical Committee

Natural Gasoline Association of America, April 14, 1943

H. H. BEESON, Chairman

IN MY report to the industry at our last year's convention in Tulsa, on May 14, I began my remarks by stating that during the past year the natural-gasoline industry had been subjected to a somewhat strenuous condition, as you well know. I can think of no better introduction now than that, with the exception of crossing out the word "somewhat," for you well know how busy all of us are, having suffered losses in our technical staffs and the rest of us having had to take on additional work. During the past year we have held only two meetings against our usual schedule of having one meeting per month. Much of our work has been carried on by correspondence and by meetings of subcommittees, and I believe that we have accomplished considerable during the past year.

At the present time we have two major projects which are current. The first is the Fractional-Distillation Project, which was begun in the fall of 1939. Mr. Montgomery is chairman of this subcommittee and will review the current year's work in his report.

Our other project is the study of plant-control tests for the determination of sulphur compounds in liquefied petroleum gases. Mr. Merle Church is chairman of this subcommittee. Our regular liquefied petroleum gas standard specifications and test methods provides a test for total sulphur. This test is somewhat laborious and takes some time and it must be run in a laboratory with special apparatus. There is a need in the gasoline plant for some easy and rapid test methods which may be run as a qualitative test for free sulphur, hydrogen sulfide and mercaptans for plant control. It is with this view point that we began studying this project. Several test methods are being studied by the subcommittee and they will appreciate receiving outlines of any test methods which you may have found satisfactory in your own plant control. Please send these suggestions either to the association office at Tulsa, or to Mr. Church, c/o Shell Oil Company at Houston.

The baby we are proud of this year is our Book of Standards. These books were only off the press Monday and so they are brand new to the industry at this time. The credit for this book is not necessarily due the present technical committee, since most of the individual standards have been brought out in years past and have been in use, but this is the first time all of these standards have been brought out in this convenient form, all in one cover so that they may be available for ready reference. In talking to our chairman, he tells me that the idea is not a new one, but that it had been considered years ago. I understand one point they could not agree on was whether to bring it out in its present size, or in a small three-by-seven-inch phamphlet size, like our first gas-testing code. We believe that you will find the present form convenient for your uses. This book not only contains the standards brought out by the technical committee, but also contains all of the standards of the association, part of which have been developed by the Gas-Testing Committee and the High-Pressure Gas Division.

I wish briefly to go over the book, which includes not only the standards of the association, but also the ASTM and API standards pertaining to natural gasoline. The latter are reproduced with the permission of these organizations. Some of these methods have long been standards of the association which has participated in their development. They are included to make the book as complete as possible. The table of contents is as follows:

Specifications and Test Methods for Natural Gasoline.

Doctor Test.

Standard Table of Physical Contents for the Paraffin Hydrocarbons.

Liquid Petroleum Gas Specifications and Test Methods.

Standard Factors for Volume Correction and Specific Gravity Conversion of Liquid Petroleum Gases and Volatile Gasolines.

Method for the Determination of the Specific Gravity of Volatile Hydrocarbon Products by the Hydrometer.

Specific Gravity of Gas by the Balance Method.

Testing Natural Gas to Determine the Natural Gasoline Content Thereof—Charcoal Adsorption.

Testing Natural Gas to Determine the Natural Gasoline Content Thereof—Compression Method.

Tentative Standard Method for Calculation of High Pressure Gas Measurement.

A. S. T. M. Section:

Vapor Pressure of Natural Gasoline.

Distillation of Natural Gasoline.

Distillation of Gasoline, Naphtha, Kerosene and Similar Products.

Color of Refined Petroleum Oil by Means of Saybolt Chromometer.

Gravity of Petroleum and Petroleum Products by Means of the Hydrometer.

Detection of Free Sulphur and Corrosive Sulphur Compounds in Gasoline.

When other test methods and specifications are adopted by the association, every owner of a copy of this book of standards will be notified. He may purchase the new standard and keep his book of standards up to date. Copies of the book of standards may be obtained for $4.00 to members and $5.00 to nonmembers. This price may seem a little high to you, but please remember that considerable expense has been incurred in the compilation and printing of the various individual standards and also that you will save money by buying the complete book, rather than buying the individual standards.

In closing, I wish to give my thanks to other members of the technical committee for their cooperation and to various companies who have made available their facilities and cooperation in the various studies we have made during the past year.

Progress Report of the N.G.A.A. Low Temperature Fractional Analysis Project

H. A. MONTGOMERY

Many of you know that the aim of this project is to improve the reproducibility of low temperature fractional analyses made by different laboratories. This object is becoming of greater importance yearly because of the growing demand and importance of the lighter fractions in natural gas, and a desire for greater plant extraction efficiencies. To date, after four years work, a total of nine sets of samples has been analyzed by the participating laboratories. A tentative standard procedure was written two years ago, after the results of the first five samples had been correlated. We are now testing the merits of this procedure, and hope that it will be possible to revise our tentative standard this coming year, if the conclusions from our correlations show this to be necessary.

Since our convention last year, one additional sample has been analyzed. We had hoped that it would be possible to analyze two samples. Special care was taken to be sure that this fourth sample in "B" series would not contain as much air as the preceding three samples. The fourth sample contained much smaller percentages of air than the other three, but the results of the correlation show about the same average percent deviation from the most probable analysis as the three preceding "B" samples. The average percent deviation for all components of all laboratories using N.G.A.A. tentative procedure on B-4 was 4.51. The same aver-

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age for a similar group in the first three samples was 4.26. Just as in the other samples of "B" series, the results secured by using the tentative procedure showed a smaller average deviation than the results secured on samples run by the various methods usually used in the different laboratories, therefore, it may be said that the results from sample B-4 confirm the results found on the preceding "B" samples, and that we might be justified in now drawing some conclusions. Before this can be done, however, the correlations of the individual analyses should be integrated for the whole "B" series. This will probably take a good part of the coming year. In some ways, this is fortunate, because many laboratories are far behind in their work and we will not be adding to their burden.

Our progress the past two years has been considerably slower than at the start, for the usual reasons nowadays. However, we are making some progress, especially because of the splendid cooperation between the participating laboratories.

Tests on a Method of Determining Specific Gravity of Two-Phase Gases

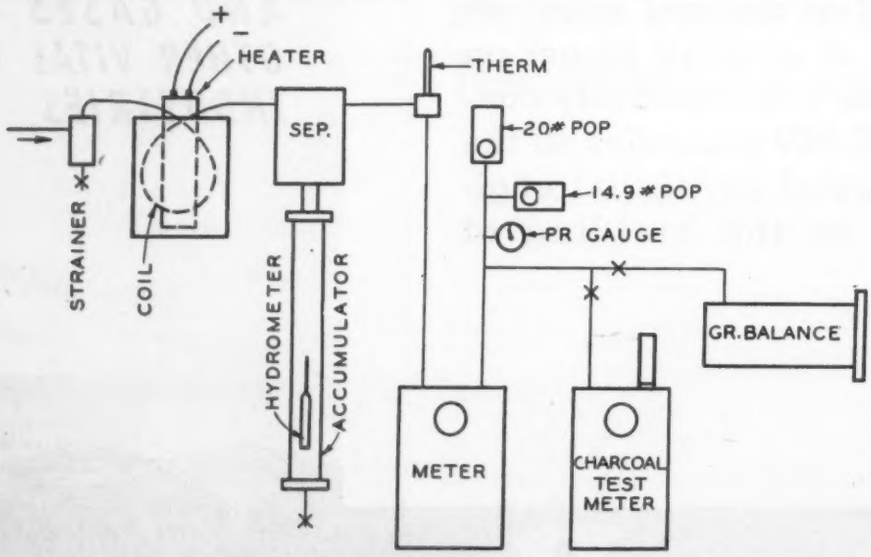
D. A. SILLERS, Lone Star Gas Company

During the committee tests at Corpus Christi a sample of gas from the Amco tip was tested by means of the Distillate Well Tester. The specific gravity obtained was .676. The following day a sample from the "Bazooka" device showed a specific gravity of .680, which indicated a slightly higher liquid mixture in the sample from this device. The plant superintendent advised that .680 is the specific gravity used at the plant as determined by analysis.

The apparatus was examined by various members of the committee, and a number of suggestions were made to improve the details affecting operation. Difficulty was had in obtaining a supply of hot water for the coil bath without undue hazard from fire. Since the test, a thermostatically controlled electric heater has been designed which operates from a six-volt storage battery. A battery will handle up to four tests in a day and could be recharged during the night. The heater is equipped with a switch which operates under the transformer oil used in the bath, so as to eliminate danger of sparks when connecting or disconnecting from the battery. The 1-inch accumulator was found to be so large that considerably over an hour was required to run the test where the gas had a content of approximately 27 barrels per million. A new accumulator is being made with an inside diameter of ⅝-inch and special hydrometers are being made ½-inch in diameter and 4½ inches long. With this new accumulator and new hydrometer, it will be possible to complete a test within an hour on gases with a content as low as 2 barrels per million.

While running a test on the sample from the "Bazooka" device, a charcoal test of the residue gas was made, showing a content of .6192 gallons per thousand. This, combined with the accumulator yield of .527, gave a total distillate content of 1.146 gallons per thousand or 26.5 barrels per million. The four full-scale separator tests averaged .819 gallons per thousand, which combined with a charcoal test of .308 gallons per thousand, gave a total of 1.127 gallons per thousand. However, there was so much variation in the full-scale separator tests that a good comparison cannot be obtained.

We believe that by the time the next tests are conducted by the committee, the apparatus will be perfected to the extent that it can be used under all conditions as a standard for determining the specific gravity of two-phase gases. It should be noted that the specific gravity, as determined by the tests, is not as sensitive as the distillate-content tests. Where the specific gravity of the residue gas is .642 and the specific gravity of the two-phase gas is .680, it will be noted that the accumulator liquid accounted for .038 in the total result, so that a small error made in conducting the test would be reduced to about 5½ percent of that error in the final result. The theory of operation and the calculations involved have been thoroughly checked and found to be correct.



Sillers Distillate Well Tester

The use of the Distillate Well Tester for determining the distillate content of the gas was not one of the primary objects of the tests at Corpus Christi. However, the device seems most practical for the purpose. The major problem before the committee is still that of obtaining a representative sample. The writer has designed a mixing device in which are installed heavy baffle plates, so arranged that it is believed that the gas and liquid will be so thoroughly mixed that a sample can be obtained from any part of the flowing stream and taken off at any desired rate, and which will be an accurate representative sample. The total area of all openings in the baffle plates is greater than the area of the inlet pipe, so that there should be no appreciable pressure drop, and the device should operate equally well at any pressure or any rate of flow. This device will be tested, and reported on at the next meeting of the committee.

Industry's Accident Record Is Improved

Despite the disorganizing effects of wartime conditions, the annual summary of injuries in the petroleum industry for 1942 shows lower frequency and severity rates than for 1941, according to figures compiled by the American Petroleum Institute Department of Accident Prevention. The 9-percent reduction in severity, as well as the slight reduction in frequency, is especially noteworthy because of the upward trend in accident rates for many industries.

The 1942 oil-company frequency rate of 11.72 was only 1.1 percent above the all-time low frequency figure of 11.59 reported for 1940. The 942 severity rate of 1.31 was the lowest on record. The 104 fatalities and permanent total disabilities for 1942 were the equivalent of 31 per 100,000 employes, as compared with 33.9 per 100,000 reported for 1941, or a decrease of 8.6 percent.

The 1942 report includes 180 oil companies employing 335,328 persons, which is 8 more companies and 2,206 more employes than were included in the 1941 annual summary.

The most notable improvement in 1942 is reflected in the ocean and coastwise service of marine departments. The frequency of disabling injuries in this service dropped to 16.76 in 1942 from 19.04 in 1941. The severity dropped to 2.02 in 1942 from 2.29 in 1941.

The severity rate in refining dropped to 1.21 in 1942 from 1.82 in 1941.

Injury index, as used in the accompanying table, is the frequency rate plus the severity rate per 10,000 hours worked. Frequency rate is the number of disabling injuries per 1,000,000 hours worked. Severity rate is the number of days lost per 1,000 hours worked.

The annual summary of disabling injuries in the petroleum industry for 1942, giving detailed figures for each department, is available, on request, from the American Petroleum Institute's Department of Accident Prevention, New York.

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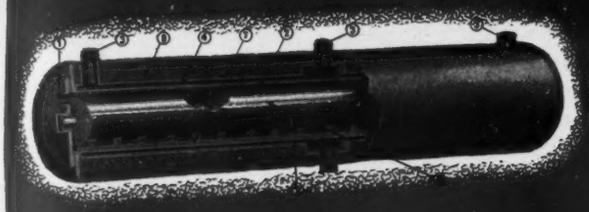

How THE VOTATOR WORKS:

This cut-away view of the Votator heat transfer cylinder illustrates how a liquid or viscous material is pumped in connection (1) thru annular space (2) and out connection (1) at the opposite end, depending upon the direction of flow desired. The heating or cooling medium enters at connection (3), passes thru annular space (4) and out connection (3). (The actual piping arrangement is determined by the type of heating or cooling medium used and the direction of flow required) The mutator shaft (6) carrying scraper blades (7) is motor driven, causing blades to scrape film from surface of heat transfer tube (5) several hundred times a minute.

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Heat transfer takes place in seconds. • Continuous, rapid flow of product. • Reduces reaction time. • Fully closed system • Uniform temperature, accurately controlled. • Simultaneous mixing, emulsifying or aerating. • More economical. • Saves critical materials and refrigeration load.

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Manufacturers of oil products, aviation gasoline, chemicals, plastics, viscous liquids and similar materials are urged to investigate the remarkable advantages and performance records of Votator heat transfer equipment.

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To the left is illustrated the heart of the Votator, the heat transfer tube, with a brief description of the simple and efficient way it works.

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ABSTRACTS OF PAPERS BEFORE DIVISION OF PETROLEUM CHEMISTRY OF THE AMERICAN CHEMICAL SOCIETY

Detroit, Michigan, April 12-16, 1943

The Laboratory Evaluation of the Potential Service Performance of Lubricating Oils. GEORGE W. WATERS AND ELDER C. LARSON, *Wood River Research Laboratories, Shell Oil Company, Wood River, Illinois.*

The corrosion and stability apparatus and method of test are introduced as means for the preliminary evaluation of the quality of lubricants. The distinctive feature of the test is the use of a felt wiping action on the bearing surface to simulate the action of the journal in the engine. Application of the test to twenty oils upon which extensive engine data have been reported establish it as capable of predicting the oxidation stability and potential corrosivity of lubricants with accuracy sufficient to warrant the use of the test as a useful and reliable tool, both in research and control, to eliminate much of the more costly and more time-consuming engine testing.

The Existent Corrosivity and Potential Corrosivity of Lubricating Oils. GEORGE W. WATERS AND HUGH D. BURNHAM, *Wood River Research Laboratories, Shell Oil Company, Inc., Wood River, Illinois.*

Bearing corrosion is analyzed into two concepts: "existent corrosivity" which is that occurring by virtue of the instantaneous chemical state of a lubricant, and "potential corrosivity" which is that occurring under conditions, representative of those of service, which lead to the simultaneous oxidation of the oil. The effects upon both types of corrosivity of temperature, time, the nature of the oil, concentration of reactants, and the physical factors of the tests are described. The important function of protective lacquer films in preventing corrosion and the interference with their action by detergents are demonstrated.

Properties of Mixtures of High Molecular Weight Hydrocarbons. R. W. SCHIESSLER, D. G. CLARKE, C. S. ROWLAND, C. H. HERR, AND F. C. WHITMORE, *The Pennsylvania State College, State College, Pennsylvania.*

The laws of mixtures governing viscosity and density have been studied for three binary systems (each containing three mixtures) of pure hydrocarbons of high molecular weight in the 26- to 28-carbon-atom range. In addition, three complex mixtures of pure heavy hydrocarbons have been prepared, the components having from 25 to 32 carbon atoms per molecule.

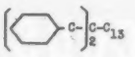
Complex mixture No. 1 contains 22 hydrocarbons, mixture No. 2 is made up of 17 components, and mixture No. 3 is a blend of Nos. 1 and 2, therefore containing 39 compounds in all. The properties reported for these multicomponent mixtures are as follows: the kinematic viscosities at 68° F., densities and refractive indexes at 20° C., kinematic viscosity indexes, aniline points, and cloud and pour points. Method of predicting these constants (except cloud and pour points) from the properties of the pure hydrocarbons by use of mole-fraction, weight-fraction and volume-fraction data are compared. Following are the names and skeletal structures of the hydrocarbons contained in the various mixtures:

Binary Systems

1. Mixtures No. 63/65:

9-n-Octyleicosane

No. 63



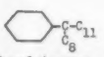
1-Cyclohexyl-2-cyclohexylmethylpentadecane

No. 65

2. Mixtures No. 67/78

11-Neopentylheneicosane

No. 67



9-Cyclohexyleicosane

No. 78

3. Mixtures No. 22/3:

6,11-Di-n-amylhexadecane

No. 22

7-n-Butyldocosane

No. 3

Complex Mixtures

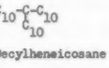
1. *Complex Mixture No. 1 (22 components):*

Contains compounds Nos. 3 and 63 (for structures, see above).

7-n-Hexyldocosane

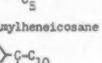
9-n-Octyldocosane

11-n-Decyldocosane



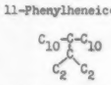
11-n-Decylheneicosane

9-n-Octylheptadecane



11-n-Amylheneicosane

7-n-Hexyleicosane



11-Phenylheneicosane

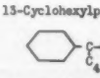
11-Phenyl-10-heneicosene

11-(3-Pentyl)-heneicosane

11-Cyclohexylheneicosane

11-Cyclopentylheneicosane

13-Phenylpentacosane



13-Cyclohexylpentacosane

3-Cyclohexyleicosane

5-Cyclohexyleicosane

7-Cyclohexyleicosane

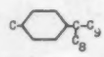
3-Phenyleicosane

9-n-Octyl-8-heptadecene

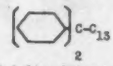
5-Phenyleicosane

2. *Complex Mixture No. 2 (17 components):*

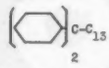
Contains hydrocarbons Nos. 22, 65, 67, and 78 (for structures, see above).



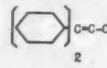
9-p-Tolyloctadecane



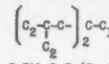
1,1-Dicyclohexyltetradecane



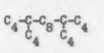
1,1-Diphenyltetradecane



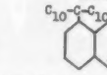
1,1-Diphenyl-1-tetradecene



3-Ethyl-5-(2-ethylbutyl)-octadecane

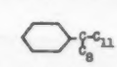


5,14-Di-n-butyloctadecane

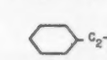


11-a-Decalinheneicosane

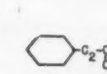
7-Phenyleicosane



9-Phenyleicosane



9-(2-Phenylethyl)-heptadecane



9-(2-Cyclohexylethyl)-heptadecane

The physical constants of these hydrocarbons pertaining to the mixture work are tabulated.

The research on these mixtures revealed the following:

The viscosity of a mixture may be predicted from the viscosities of the components with a fair degree of accuracy by assuming the additivity of fluidities, and using weight-fraction data in the calculations. The accuracy decreased the greater the difference in the viscosities of the components. Approximately the same degree of accuracy was achieved by using ASTM Chart D (D341-37T) as a blending chart.

The predictability of kinematic viscosity index, assuming it to be a linear function of the mole-, weight-, or volume-fraction, was not satisfactory.

The density of a mixture of pure heavy hydrocarbons was best estimated from weight-fraction data as a linear function.

Volume-fraction data gave the most accurate values for the refractive indexes of these mixtures.

The aniline points of two of the complex mixtures were best calculated assuming the aniline points of the pure components to be linear functions of the weight- or volume-fractions.

Reproducible cloud and pour point data were obtained for the complex mixtures.

Viscosity of Solutions in Branched Paraffins. E. H. MCARDLE AND A. E. ROBERTSON, *Esso Laboratories, Research Division, Standard Oil Development Company, Elizabeth, New Jersey.*

Solutions of an alkyd type resin, and of a natural and two substitute rubbers,

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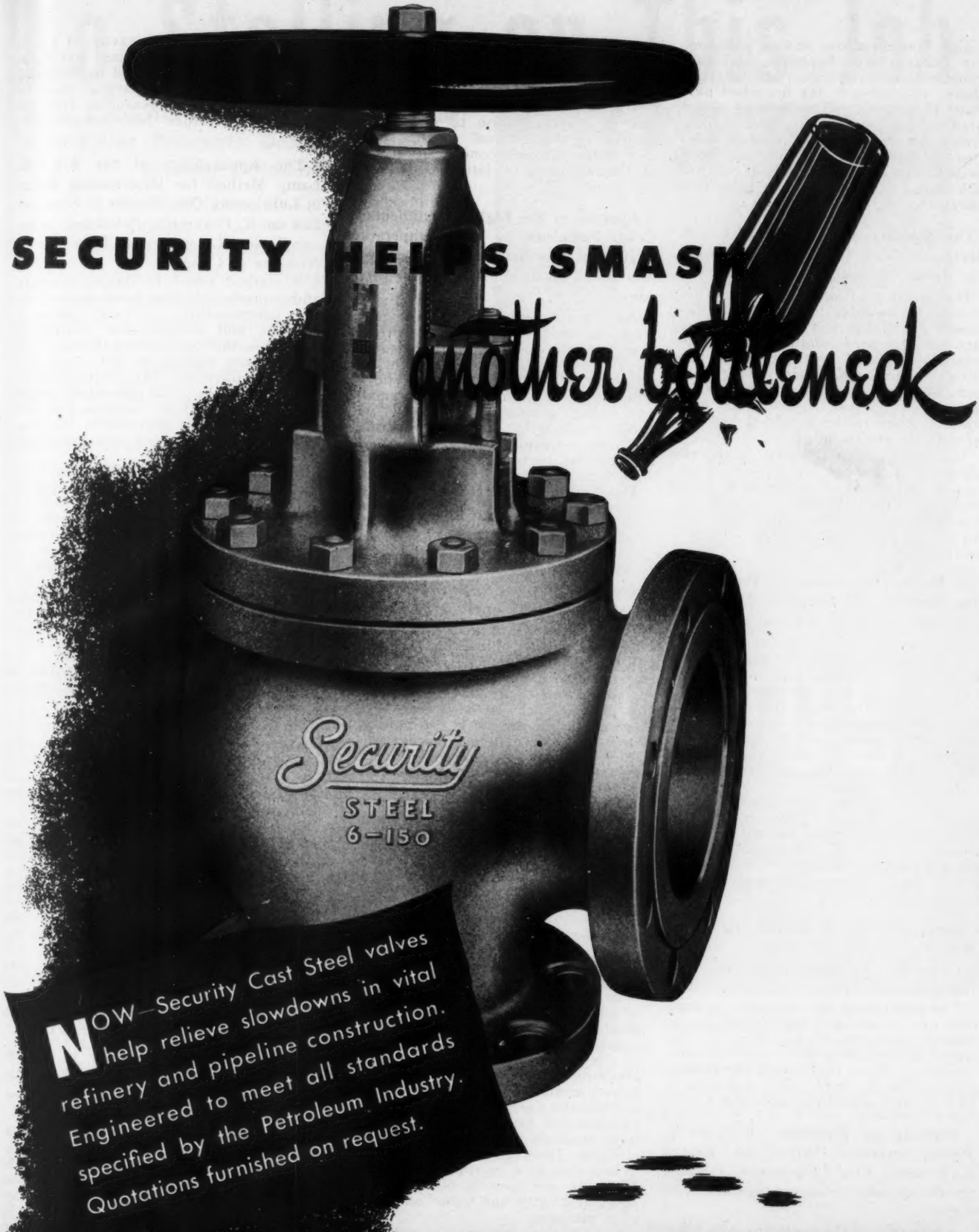

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at high concentrations in two pentanes, four hexanes, five heptanes, and two octanes, show much higher absolute and relative viscosities in the branched paraffins than in the corresponding normal paraffins. An arbitrary method of predicting the viscosity of the resin solutions in branched paraffins has been devised; and an attempt made to use such values in a method of hydrocarbon analysis.

The Stability of Furnace Oil. A. B. Hersberger, H. C. Cowles, and B. Zieber, *The Atlantic Refining Company.*

The fouling of domestic oil burner systems by unstable furnace oils is discussed. A stability test is described and data are presented relating this test to results obtained by circulating oils through the essential parts of a gravity feed burner system, the latter results having been found to correlate with practice. Data on both refined and unrefined oils are included.

The stability test is based on the reaction of oils to two metal pairs, iron-copper and iron-lead, under controlled conditions. The test was originally designed for straight-run oils and its limitations in regard to cracked oils are pointed out.

A Method for Evaluating the Oxidation Stability of Distillate Fuel Oils. J. R. Sabina, R. O. Bender and E. L. Korb.

A method for measuring the progress of fuel oil oxidation under controlled conditions has been developed which can be used to study the effect of chemical treatment of contaminants, of storage conditions, and of chemical adjuvants on fuel oil stability. Data are presented to illustrate each of the applications. Equipment and technique adopted by A.S.T.M. for gasoline testing is used. Data are also presented to show the correlation obtained between storage tests, field experience, and the present method. The authors believe that it is a useful tool for the study of fuel oil deterioration.

Determination of Butane - Isobutane Mixtures. Alfred W. Francis, *Socony-Vacuum Oil Company, Paulsboro, New Jersey.*

The percentage of isobutane in mixture with n-butane is determined by the critical solution temperature of the liquid hydrocarbon with o-nitrotoluene, which is a linear function of the composition. The C. S. T. with n-butane is 12.5° C. and with isobutane 32.8° C.

Stability of Butadiene. Richard F. Robey, Herbert K. Wiese and Charles E. Morrell, *Esso Laboratories, Standard Oil Development Company, Elizabeth, New Jersey.*

The study of the reactions which butadiene undergoes during storage and plant processing has been made. The two reactions of most interest are: (1) dimerization by a Diels-Alder type condensation, and (2) polymerization to plastic materials of high molecular weight. The first reaction is bimolecular and homogeneous in the liquid phase under a variety of conditions. Bimolecular reaction rate constants have been determined for a range of temperatures and compared with the constants for the gas phase reaction. The magnitudes of these constants are quite close. Formation of higher molecular weight polymers is peroxide-catalyzed. For a number of peroxide catalysts the rate of polymerization to plastic substances is proportional to the square root of the peroxide concentration. Data on the rate of peroxidation of butadiene are given.

Analysis of the Light Constituents in Crude Petroleum by Low-Temperature Fractional Distillation. R. J. Askevold and M. S. Agruss, *The Pure Oil Company.*

Auxiliary equipment is described which is used in conjunction with the low-temperature fractionating column for the determination of the light constituents in crude petroleum. The results obtained by means of this smaller equipment compare very well with those obtained by pilot plant operation on larger quantities of sample. The method can be used for the calculation of material balances on distillation and cracking units in oil refineries where it is desirable to know the composition of the light gases occurring in the original crude oil charge.

The Viscosities of the Methane-Propane System. Leo B. Bicher, Jr., and Donald L. Katz, *University of Michigan.*

The viscosities of methane, propane, and four of their binary mixtures (20, 40, 60, 80 mole % CH_4) have been determined with an average error of 3.2 percent at eight pressures (400 to 5000 lbs. per sq. inch) at each of five temperatures (77° to 438° F.) using a rolling ball—inclined tube type viscometer. These data are correlated by the three variables, molecular weight, pseudo-reduced temperature, and pseudo-reduced pressure, with an average deviation of 2.9 percent. This correlation may be used to obtain the viscosity of any light paraffin hydrocarbon or hydrocarbon mixture with an average error of less than 3.5 percent.

Surface Tension of n-Heptane and n-Butane Containing Dissolved Nitrogen. Gordon J. Reno and Donald L. Katz, *University of Michigan.*

The surface tensions were measured of n-heptane containing dissolved nitrogen at 200, 500, and 1000 pounds per square inch at 77°, 131°, and 185° F. and of n-butane containing nitrogen at these pressures at 77° F. The nitrogen, dissolved at 1000 pounds per square inch, reduces the surface tension of the pure hydrocarbon from 20 to 29%. The data were used to compute a parachor for nitrogen dissolved in n-heptane of 41. When dissolved in n-butane, the paracoor for nitrogen is 60 which is in agreement with the value obtained for pure nitrogen.

An Improved Automatic Gas Effusiometer. Leonard C. Drake.

An improved automatic gas effusiometer based on the measurement of the time for the gas to pass through a standardized orifice (Schilling method) is described. The apparatus employs salt solution as the confining liquid and a series-parallel electric circuit to start and stop an electric stop clock. Electric relays and strategic mercury are not required. The specific gravity of gases, including those containing hydrogen sulfide, may be determined to the third decimal place. The apparatus may be adapted for use in measuring time intervals with other laboratory equipment.

The Applicability of the A.S.T.M. Lamp Method for Determining Sulfur in Lubricating Oils. Ernest L. Korb and Edward K. Cornelius, *Petroleum Chemicals Testing Laboratory, E. I. du Pont de Nemours & Company.*

A method which is simple, accurate, and reproducible has been evolved for the determination of total sulfur in straight and compounded lubricating oils. This method employs the A.S.T.M. sulfur lamp equipment with only one slight modification. The procedure comprises burning a 75:25 percent by weight mixture of A.S.T.M. naphtha and lube oil and the sulfur liberated in the combustion is determined gravimetrically as $BaSO_4$.

Results on a number of samples evaluated in the A.S.T.M. sulfur bomb by other cooperating laboratories did not show particularly good agreement. In general, the modified lamp procedure gave results close to the average, or slightly higher than those obtained by the conventional method.

The method has since been extended successfully to all types of heavy fuel oils, so long as they are free of suspended material.

Determination of Disulfide Sulfur in Gasoline. George W. Ayres and M. S. Agruss, *The Pure Oil Company.*

It has been shown that organic disulfides have an adverse effect on the susceptibility of gasolines to tetraethyl lead and therefore the determination of organic disulfides in gasolines is of considerable importance.

No completely satisfactory method for the determination of such small quantities of disulfide sulfur in gasoline is available in the literature. The reduction of disulfides in the presence of zinc and acetic acid is fraught with many difficulties which have been overcome by (1) the use of a trap to prevent the escape of volatile mercaptans formed, (2) the shortening of the time necessary for complete reduction of the disulfides to mercaptans, and (3) the direct titration of the acetic acid-gasoline mixtures without a preliminary water wash.

Determination of Water in Hydrocarbon Gases. Harry Levin, Karl Uhrig, and F. M. Roberts, *The Texas Company, Beacon, New York.*

A method is described for determining water (vapor or dissolved) in hydrocarbon gases. It is based on the observation that when a gas containing moisture is contracted with cold dehydrated acetone, the water is retained by the acetone in which it can be determined by an acetyl chloride method. Olefins and diolefins do not interfere and provision is made for correcting for interference by acidic or basic constituents of sample.

Method for Determining Oxygen in Hydrocarbon Gases. Karl Uhrig, F. M. Roberts, and Harry Levin, *The Texas Company, Beacon, New York.*

A method is described for determin-

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ing oxygen in concentrations of 0.001 to 5 percent. Oxygen is reacted with copper wetted with ammonia-ammonium chloride solution, the resulting mixed oxides are dissolved in the same solution, reduced to cuprous form, and copper is determined iodometrically as a measure of oxygen in the sample. The method gives accurate results in saturated and unsaturated hydrocarbon gases. Sulfur dioxide, hydrogen sulfide, and mercaptans must be removed and means for doing so are provided.

The method is based on well-known reactions but many modifications have been made, in technique and equipment, which have produced an accurate usable method.

Thermal Value of Gasoline Method of Test. HARRY LEVIN AND CHARLES J. SCHLAGEL, *The Texas Company, Beacon, New York.*

A method is described for determining the calorific value of gasoline in an oxygen bomb calorimeter. It involves combustion of the sample contained in a sealed glass bulb wetted with lubricating oil of known calorific value. The technique secures prompt firing, clean burning, and reproducible results.

Absorption and Stripping Design Method for Hydrocarbons. W. C. EDMISTER.

Equations have been developed for making hydrocarbon absorption and stripping design calculations. Effective absorption (or stripping) factors, obtained by analytical equations from the terminal (top and bottom tray) conditions, are used in this method. Absorption and stripping efficiencies are computed by equations using these effective factors and taking into account the compositions of the wet gas and the lean oil in the case of absorption and rich oil and the stripping gas in the case of stripping.

The application of this method is outlined. For components appearing in both wet gas and lean oil it is frequently necessary to apply both the absorption and the stripping equations. A comparison of this method and other methods with plate-to-plate calculations indicates that this method is an accurate and rapid short cut.

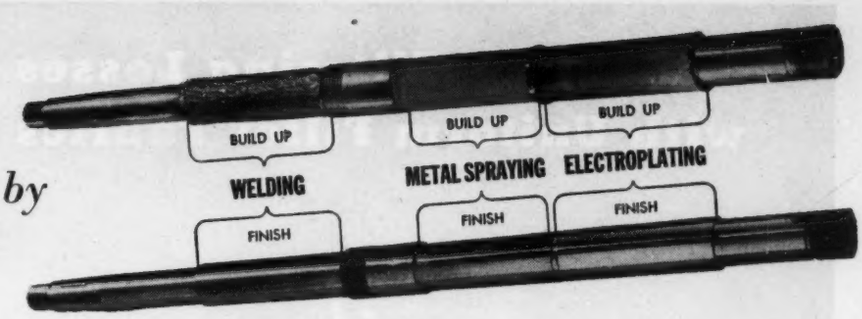
Catalytic Cracking by the Fluid Catalyst Process. E. V. MURPHREE, C. L. BROWN, H. G. M. FISCHER, E. J. GOHR, AND W. J. SWEENEY.

The fluid catalyst process represents a new chemical engineering technique and has wide application to many industrial catalytic and noncatalytic operations. The present paper is concerned only with the application of this technique to catalytic cracking of petroleum fractions.

When oils are cracked, carbon is deposited on the catalyst, reducing its activity and making necessary its removal by burning with air. In the fluid catalyst cracking process the catalyst is handled as a fine powder, in such a way that it is kept in a fluidized condition at all times, in which form it may be handled substantially as a liquid. The catalyst is conveyed through the reactor by the oil vapor, after which it is separated in dust recovery equipment, with the product vapor flowing to conventional distillation equipment. The carbonized catalyst then flows down a

PART 2–

Re-conditioning by building up and finishing



Putting worn pump rods, shafts and wearing sleeves back into shape usually may be done by machining and refinishing, as described in Part 1 of this series last month.

However, if too much metal must be removed to clean up the worn section, the shaft may be unduly weakened.

If a shaft shows a tendency to "whip"...or if a reciprocating pump rod tends to "bow" on pressure strokes, the pump manufacturer should be consulted. He may advise building up the shaft before machining.

If so, a choice may be made from three methods: *welding, metal spraying, or electroplating.*

Space does not permit a complete description of these operations, but the advantages of each method are given below.

Rods and shafts of Monel or "K" Monel can be built up for re-finishing by the methods given here. The excellent mechanical properties of the Monels provide an extra margin of strength, rigidity and toughness beyond the ordinary demands of normal work.

A bulletin, "New Parts from Old," that includes complete information on the above operations, together with the method of reconditioning by machining and refinishing described previously, will be sent on request.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street **New York, N. Y.**

ADVANTAGES OF WELDING

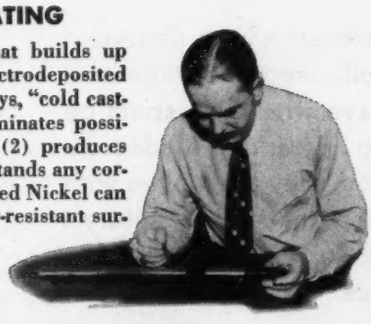
This method produces a stronger, tougher, more rigid shaft or rod than does spray coating or electroplating... and the mechanical properties of the rebuilt-by-welding shaft closely approach the mechanical properties of the original. Electric arc welding is preferred and the equipment required will be found in almost any maintenance shop.

ADVANTAGES OF SPRAY COATING

This is the simplest method of the three. For some purposes, the peculiar, porous structure of sprayed metal coatings is a drawback; it adds little tensile strength or toughness. However, in many shaft applications this porosity is considered a virtue...the pores fill with lubricant in service which is believed to account for the increased working life of the part.

ADVANTAGES OF ELECTROPLATING

Another method is "cold casting" that builds up worn parts with heavy coatings of electrodeposited nickel. Although slower than other ways, "cold casting" offers these advantages: (1) eliminates possibility of heat distortion and warpage. (2) produces a dense fine-grained deposit that withstands any corrosive condition under which solid rolled Nickel can be used. (3) makes an extremely wear-resistant surface, as the hardness of the plating can be controlled to develop tempers ranging up to several times the hardness of the original pump rod or shaft.



SUGGESTIONS FOR OPERATING PUMPS TO PROLONG LIFE OF RODS AND SHAFTS

Use a good quality of packing recommended by a good packing manufacturer for the particular type of service.

•

Before putting in new packing, make sure that every particle of the old packing is cleaned out.

•

Tighten up the packing gland evenly, back off the nuts two or three turns, and adjust them finger tight.*

•

Make sure that the gland followers do not ride on the piston rods or impeller shaft.

•

To prevent burning of the packing and scoring of the shaft or sleeves in a centrifugal pump, a small amount of water should always seep out through the stuffing box while the pump is running.

•

Two ways to make packing last longer in centrifugal pumps are to use a light grease on the new packing and to cool the stuffing box externally until the packing is "run in" and some sealing water leaks through the box.

•

When packing becomes hard and dry, do not attempt to stop excessive leakage by tightening up further on the gland. Replace packing immediately.

•

*Finger-tight is tight enough as long as the shaft or rod remains smooth and perfectly cylindrical. Shafts and rods of Monel or "K" Monel—with their qualities of high resistance to both corrosion and wear—tend to stay smooth and perfectly cylindrical longer.

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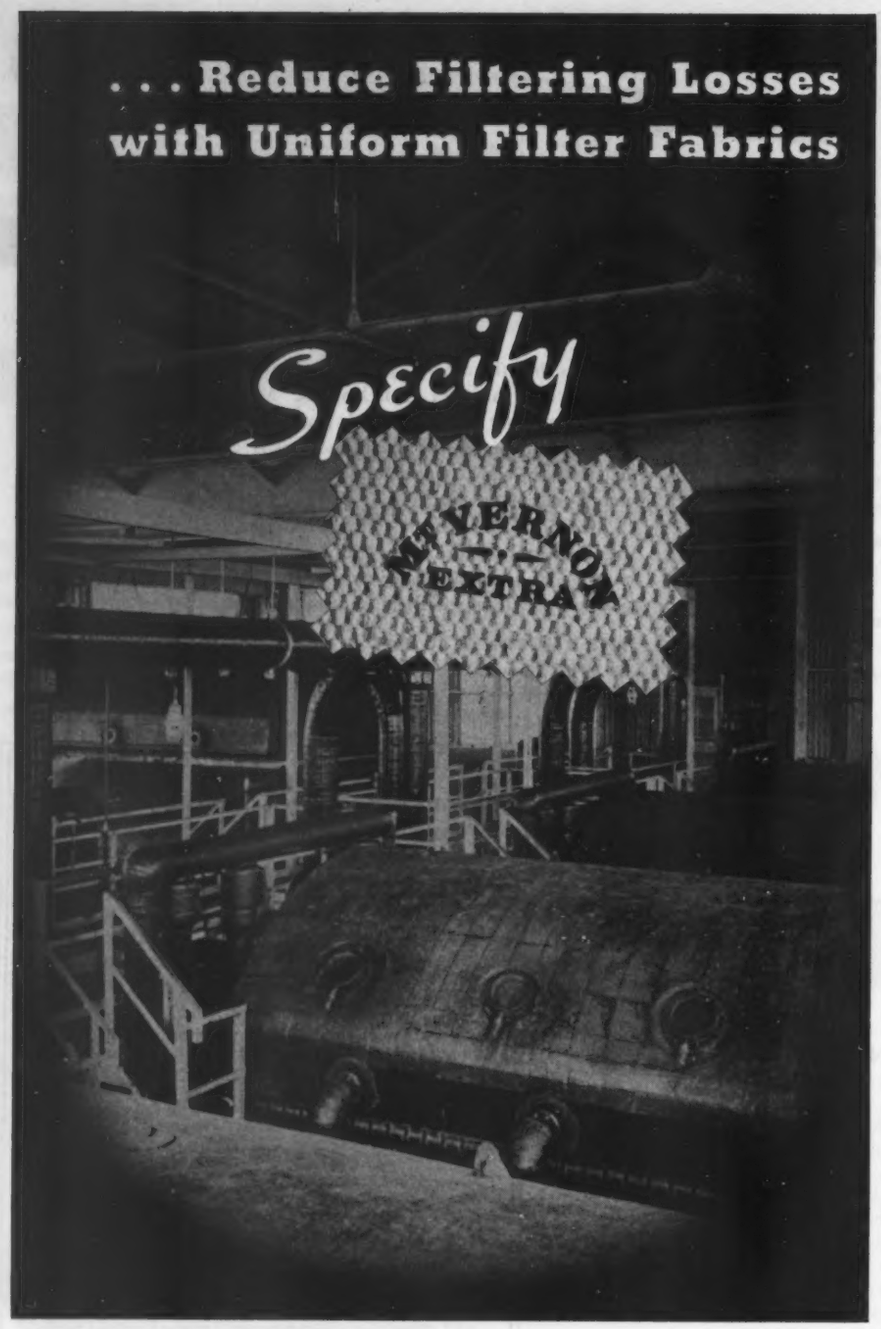

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standpipe in a high density condition, whereby its pressure is increased sufficiently to permit injection into a stream of air, which carries it to the regenerator. In the latter the carbon is burned off, after which the catalyst is separated and the flue gas vented to the atmosphere. The regenerated catalyst then passes down a second standpipe and is injected into the oil vapor going to the reactor. The process is thus completely continuous as regards oil, air, and catalyst flow.

Information is available on production of motor gasoline from a variety of charge stocks. The motor gasoline has a clear octane number of 92-94 by the CFR Research method.

Operating conditions in the process may be adjusted to the production of war products such as high octane aviation fuel, butylenes, and toluene. Gasoline fractions from the operation may be used directly as aviation base or may be reprocessed in the fluid catalyst unit or hydrogenated. Aviation fuels produced by these methods have low alkylate requirements and when so blended, and after addition of lead tetraethyl, meet highest grade aviation fuel specifications.

Three commercial plants are now in operation and have given very satisfactory performance. A large number of additional commercial units are under construction.

The Mass Spectrometer and Its Application to Petroleum Refining. O. L. ROBERTS, H. W. WASHBURN, AND L. N. LEUM.

The mass spectrometer as an analytical tool for use in petroleum refining operations is discussed. Examples of several types of mixtures which have to date been successfully analyzed by this new method are presented with comments regarding their accuracy and time required for analysis. The paper concludes with a brief discussion of several processes in which analytical data are useful in control, and in which the mass spectrometer method may prove valuable to the refiner.

Catalysts of the Montmorillonite Type. R. C. DAVIDSON, F. J. EWING, AND R. S. SHUTE, *Filtrol Corporation, Los Angeles.*

The increased demand for high octane gasolines has led to the widespread commercial employment of catalysts in petroleum processing. Although both natural and synthetic catalysts have been used, this paper discusses only those falling in the natural category. The early application of activated montmorillonitic type clay for petroleum cracking and the factors affecting the catalytic activity of clay—both as to original raw material and its subsequent treatment—are reviewed. There is also a resume of the theories of catalytic mechanisms as applied to activity and an outline of how these various conditions have led to the development of controlled natural catalysts for meeting wartime requirements. The main uses in catalytic cracking and other possible applications in heterogeneous catalysts are briefly outlined.

N.P.A. Speaker Stresses Aviation Fuel Need

The need for additional supplies of 100-octane aviation gasoline was stressed by E. D. Cumming, PWA director of refining, when he spoke to the abbreviated session which replaced the regular meeting of the National Petroleum Association in Cleveland, April 15.

"There is a wide gap," he said, "between the combat fuel which is available and that which the air forces feel they should have."

Since the refining industry made part of its contribution of aviation gasoline in 1942 by readjusting existing equipment to making ingredients for this fuel, he laid stress on further increase through ingenuity. By the end of 1943 he expects one third of the refining plants in the United States to be engaged in providing some ingredients of the aviation gasoline requirement.

The future building program was thus outlined:

"We are still working aggressively on proposals for extension of aviation-gasoline-plant facilities. At present we anticipate that we can fulfill the requirements east of the Rocky Mountains by installing only those facilities which involve the minimum of critical materials as well as minimum crude oil requirements."

Other speakers at the fortieth semi-annual meeting of the association were W. M. Holaday, aviation section PWA director of refining; Paul Ryan, chairman PIWC committee, post-war readjustments; Frank A. Watts, director PWA materials division; Robert I. Minckler, director PWA supply division; Robert H. Collacott, of OPA.

Willard H. Dow Gets Chandler Award

Willard H. Dow, president of Dow Chemical Company, Midland, Michigan, was given the Chandler Medal May 20. This is the annual award of Columbia University, given for outstanding achievements in chemistry.

THE LOOK BOX

Schaefer Vice President Of Ethyl Corporation

John H. Schaefer, general manager of the manufacturing department of Ethyl Corporation, has been elected a vice president and will have charge of traffic and manufacturing development activities along with his former duties.

Schaefer has been with Ethyl Corporation for 17 years, coming into the organization upon graduation from Massachusetts Institute of Technology in 1936.

He is a native of Buffalo but grew up in Wilmington. After high school he attended the University of Delaware where he gained his bachelor of science degree. At M.I.T. he was graduated as a master of science and spent a short time there as a chemical engineer in the research laboratory. While there he was associated with George Calingaert, who later became director of the chemical research laboratory of Ethyl Corporation at Detroit.

WPRA Group Meets At El Dorado

There was a meeting of the technical group of the Western Petroleum Refiners Association in El Dorado, Arkansas, April 29, when John H. Baird, Southwest district manager of Lubri-zol Sales Corporation, spoke on *Changes in Lubricating Oils as Influenced by Military Needs.*

NGAA Program Stresses Role of Natural in War

Although the program for the annual meeting of the Natural Gasoline Association of America in Dallas April 14, 15 and 16, was arranged in anticipation of restricted attendance, registrations exceeded 400. Some of the preliminary arrangements proved inadequate with the result changes had to be made.

The report of the technical committee and its several subcommittees the afternoon of April 14 was started in one of the smaller meeting rooms of the Baker hotel. When this room was filled and others were seeking admittance the session was halted and arrangements made for continuing it in the ballroom.

This session consisted of the following reports of work being done under supervision of the technical committee, of which H. H. Beeson, Sabine Valley Gasoline Company, Shreveport, is chairman:

The Testing of High Pressure Gases, W. L. Bowser, The Atlantic Refining Company.

Determining Specific Gravity of Two-Phase Gases, D. A. Sillers, Lone Star Producing Company.

Corrosion in Distillate Wells, T. S. Bacon and E. A. Brown, Lone Star Producing Company.

Fractional Analysis of Gases, H. A. Montgomery, Hanlon-Buchanan, Inc.

Fractional Analysis by Mass Spectrometry, O. L. Roberts, The Atlantic Refining Company.

Adsorption Fractionation, N. C. Turner, Frick-Reid Supply Corporation.

The second day was given over to the technical program, with Paul C. Coffin, Shamrock Oil & Gas Corporation, presiding at the morning session which program follows:

The Potentialities of Alkylation and Isomerization, Arch L. Foster, whose paper was read by B. R. Carney, Shell Oil Company.

Tepetate, Six Years Later, E. O. Ben-

An interesting departure in a convention program was reserved for April 16, the last day of the meeting of the Natural Gasoline Association of America. It was listed as an "Information Please" session. D. E. Buchanan, Hanlon-Buchanan, Inc., and director of District 3, PAW, had the role of interlocutor. Members of the audience wrote questions, which Buchanan placed before the panel of representatives of several of the engineering, processing and construction concerns. This panel is pictured above, left to right: A. J. L. Hutchinson, Fluor Corporation; R. P. Mase, Frick-Reid Supply Corporation; M. F. Kotzebue, Gasoline Plant Construction Corporation; R. H. Newton, Houdry Processes Corporation; M. M. Perkins, M.W. Kellogg Company; A. E. Buell, Perco Division, Phillips Petroleum Company; N. K. Rector, Petroleum Engineering, Inc.; Henry Wade, Parkhill-Wade; R. C. Fish, Stearns-Roger Manufacturing Company; Justin Wolfe, assistant counsel; Paul M. Reigorodsky, assistant director, and Frank H. Dotterweich, technical advisor, natural gas and natural gasoline division, Petroleum Administration for War.

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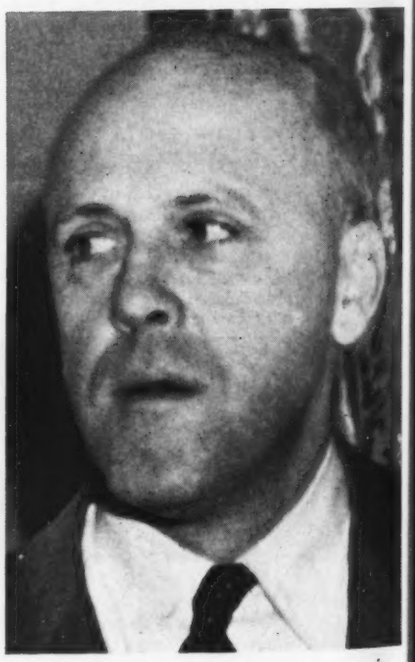
Vice presidents: H. H. Beeson, Sabine Valley Gasoline Company, Shreveport; H. A. Ells, Cities Service Oil Company, Bartlesville; R. A. Carter, Continental Oil Company, Ponca City; C. R. Williams, The Chicago Corporation, Corpus Christi, who represents the high-pressure division.

Directors elected for two years will be named for the following company members: J. S. Abercrombie Company, The Atlantic Refining Company, Carbide & Carbon Chemicals Corporation, Continental Oil Company, Cities Service Oil Company, Glazier Production Company, Lone star Producing Company, Owens-Libbey-Owens, gas department; The Parade Company, Shamrock Oil & Gas Corporation, Shell Oil Company, Union Oil Company and Virginian Gasoline & Oil Company.



H. A. ELLS, *Vice President*

nett and F. B. Haverfield, Continental Oil Company.

The Distillate Industry in the War Program, J. R. Butler, Cotton Valley Operators Committee.

H. A. Ells, Cities Service Oil Company, presided at the afternoon session when the following subjects were discussed:

Intelligent Use of Natural Resources, the report of Ray E. Miller, who served as association president for two years.

Normal Butane, R. C. Alden, Phillips Petroleum Company, whose paper was read by T. W. Legatski of the same concern.

War Products from Natural Gas and Natural Gasoline, Paul M. Raigorodsky and Frank H. Dotterweich, natural gas and natural-gasoline division of PAW.

The smoker at which members of the association are guests of the Natural Gasoline Supply Men's Association was held that evening.

A departure in program procedure came the next morning when a panel of experts were given the task of answering questions from the floor. This part of the program was "off the record."

The Hanlon Award, presented each year at the annual meeting of the Natural Gasoline Association of America, went to F. P. Peterson, Tulsa. Peterson was styled the father of the liquefied-petroleum-gas industry by Ray E. Miller, association president. Peterson retired several years ago as assistant superintendent of production for Mid-Continent Petroleum Corporation.

His interest in gas engines led him into natural gasoline in 1909. Two years later he purchased a plant for the purpose of seeking solution of the losses

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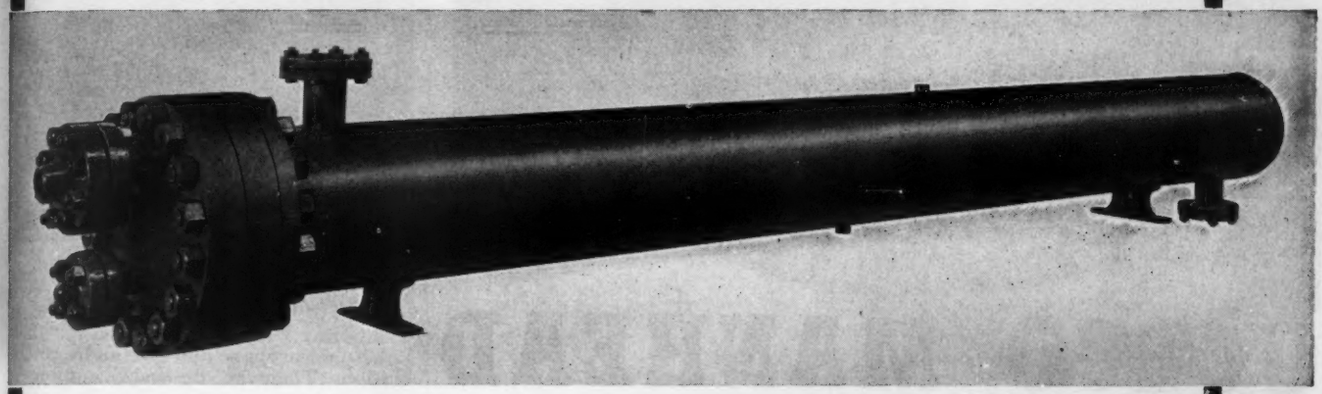

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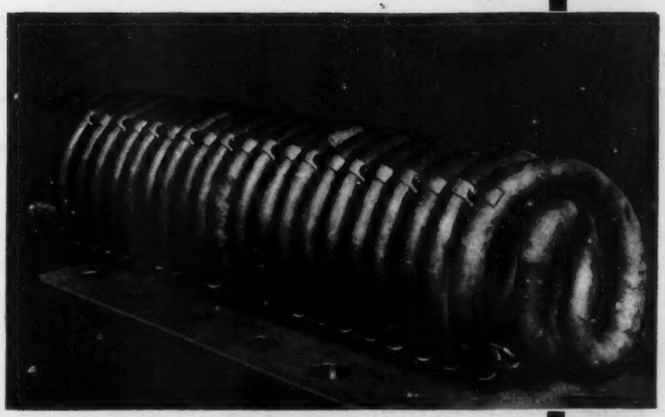

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incidental to the wasteful practice of weathering. In time he succeeded in liquefying propane and butane by refrigeration. Then he designed equipment and obtained patents on liquefication of natural gas by pressure fractionation as well as one on multiple-stage condensation for producing stable natural gasoline.

Then he applied for a patent on liquefied petroleum gas, which he described as: "a composition of matter comprising a new commercial product, gaseous at normal temperatures and atmospheric pressure but capable of being liquefied and thereafter held in containers in the form of a liquefied gas at normal temperatures and under pressure practical for storage and transportation purposes."

Middleton Promoted At Mid-Continent Plant

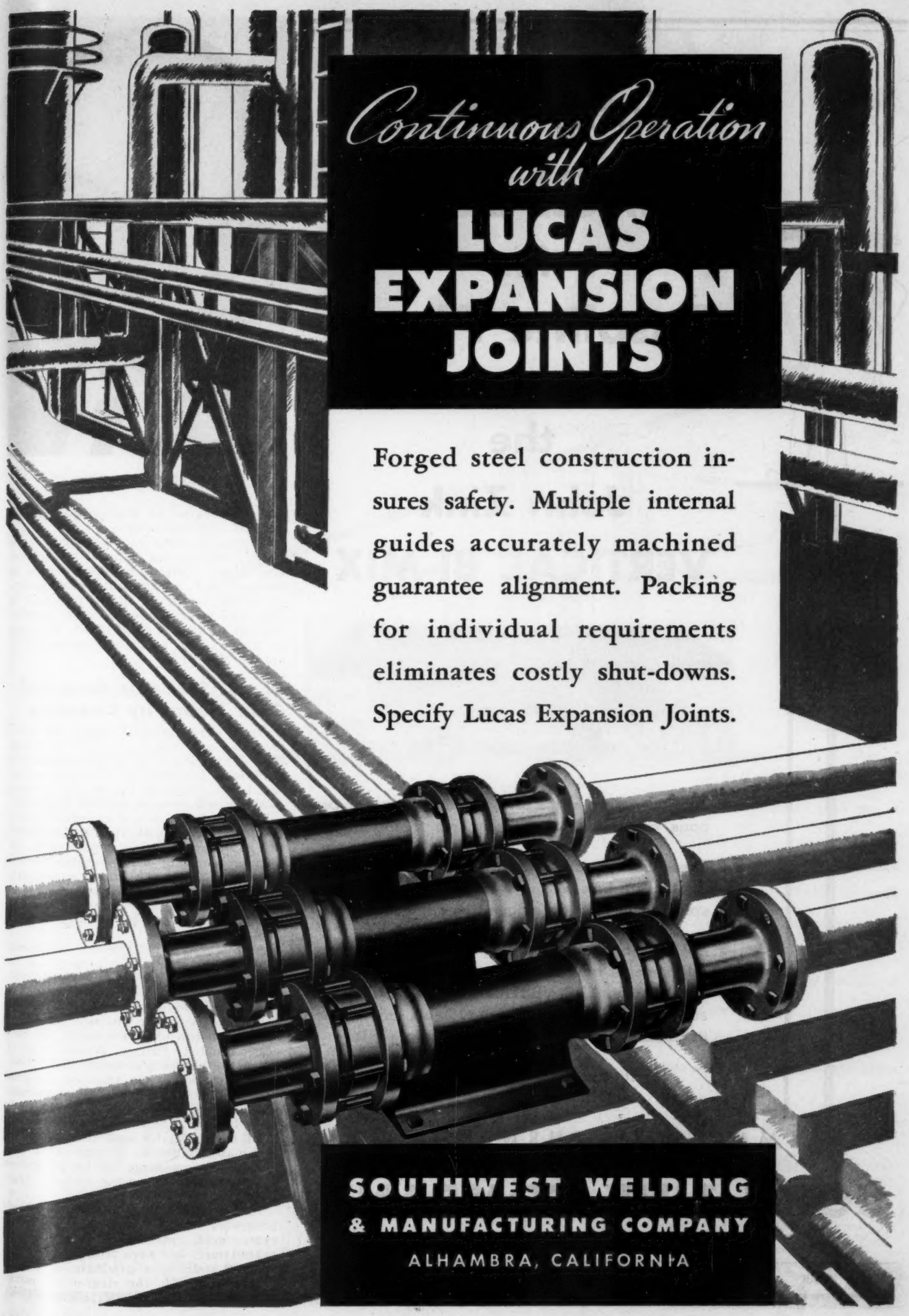
J. A. Middleton has been promoted to chief designing engineer for Mid-Continent Petroleum Corporation, with headquarters at the West Tulsa Refinery, Tulsa, Oklahoma. He was formerly chief assistant to E. M. Dons, engineering department.

Wheeldon Is Lone Star Superintendent

Harry Wheeldon has been appointed superintendent of gasoline plants for Lone Star Producing Company. He succeeds J. R. Jarvis, who died recently. Wheeldon had been assistant since 1939. Another change brought Fred Townsend, Lone Star superintendent in East Texas, to Dallas as assistant superintendent.

Both are graduates of Texas Agricultural & Mechanical College in chemical engineering.

Wheeldon joined the Lone Star organization in 1922 and has worked in most of its major gasoline plants. He became superintendent at Gainesville in 1925, serving in similar capacities in Petrolia in 1926 and at Gordon in 1927. In January, 1937, he became superintendent of gasoline plants in the Ranger area and held that position two years,



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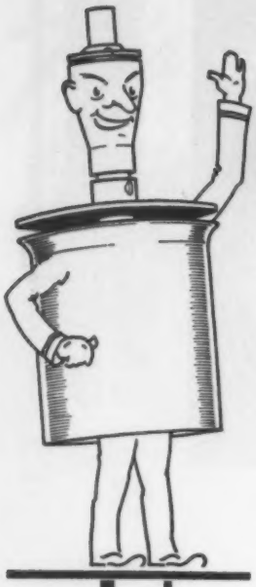

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- So designed that primary and secondary air adjustments may be made without going under the furnace. THE VERTICAL BI-MIX BURNER is so strong that workmen may walk on it when inspecting or repairing the boiler.

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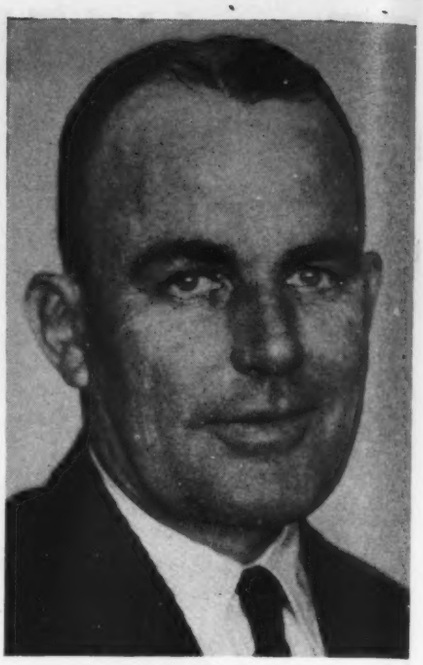

HARRY WHEELDON

when he came to Dallas as assistant general superintendent.

Townsend came into the organization in 1927 as a testing engineer in the Gordon plant. Later he was chemist at Gordon and at Petrolia. He became chief chemist of the Ranger district in 1932 and a year later became superintendent at the Gordon plant. He went to East Texas as district superintendent in May, 1941.

Dr. W. S. Landis Awarded Gold Medal by Chemists

Dr. Walter Savage Landis, vice president of American Cyanamid Company, has been awarded the gold medal of the American Institute of Chemists which will be presented at the annual meeting of the Institute to be held in May.

This medal, which is awarded annually for outstanding service to the science of chemistry, is being presented to Dr. Landis not only in recognition of his contributions to chemical engineering and development work, largely in the field of nitrogen derivatives, but also for his services to the professional side of chemistry.

Among Dr. Landis' accomplishments is the development of a method for the fixation of atmospheric nitrogen by producing ammonia from cyanamid and oxidizing it to nitric acid; and he was concerned with the engineering of the first American plant for using this process, erected during World War I, when the nation was faced with "nitrogen starvation." He likewise designed the first portable hydrogen generator for inflating military balloons, largely used by the American forces.

At this time, he was also consultant for many industrial groups who were faced with problems in the production of munitions, but were without experience in this field.

His technical developments include processes for the production of hydrocyanic acid, cyanides, ferrocyanides, dicyandiamid, and urea from cyanamid.

Dr. Landis is a graduate of Lehigh University with the degree of metallurgical engineer (1902), M.S. (1906),

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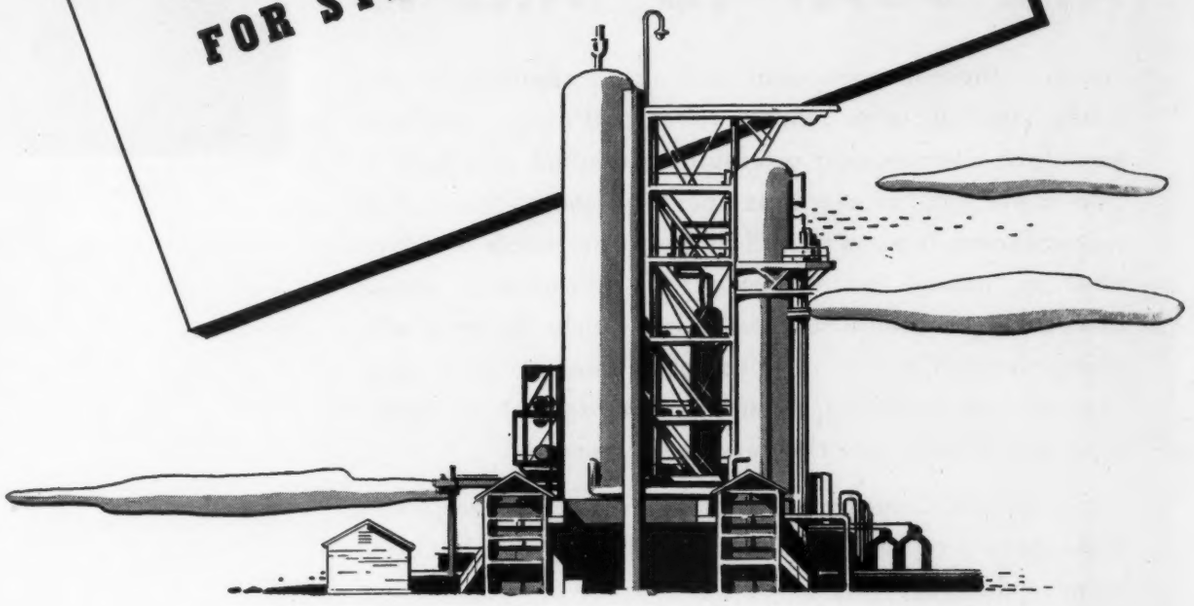

Standard Steel possesses the physical facilities and trained personnel required to fabricate pressure vessels, tanks and other types of equipment built from steel plate and used by the designers and erectors of refineries and petro-chemical plants. Acetic, phthalic anhydride and similar plants as well as the oil and synthetic rubber industry will find Standard Steel designers, engineers and structural job men conversant with the latest manufacturing practices.

For over fifteen years Standard Steel has fabricated steel plate equipment for the engineering and construction, mining and food processing fields. The comprehensive experience gained in these fields plus the services of personnel who have worked with the oil industry for many years past are at your disposal.

An opportunity to present the Standard Steel story in detail and to bid on work which we are qualified to handle is very much desired.

Write, wire or telephone for a Standard Steel Engineer who will furnish you, promptly, full information concerning any plate steel problem you may have.

STANDARD *Steel Corporation*

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STEEL PLATE FABRICATORS TO INDUSTRY OF THE WEST

WILSON TUBE CLEANERS ARE BUILT TO TAKE IT

For the efficient, economical and rapid cleaning of still tubes—and all other refinery tubes and pipes—you *must* have tube cleaners and accessories designed and built to "stand the gaff" of war time operating conditions—when tube cleaning is often put off as long as possible and then must be "rushed through" to get the still or other equipment back on stream without delay. To do the most efficient, thorough, and economical job of tube cleaning under present day operating conditions, you cannot do better than buy Wilson tube cleaners and accessories.

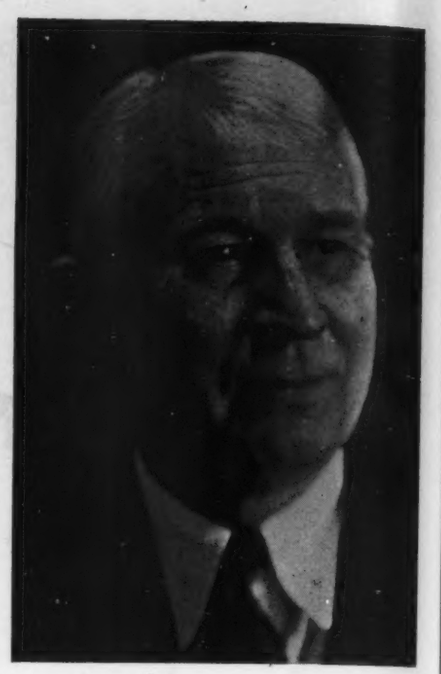
Wilson Tube Cleaners have built into them the *extra power, extra speed, extra strength* and *extra efficiency* which enable them to clean *any* kind of tube, straight or curved, of large or small diameter, faster, better and more economically.

Scores of refineries producing essential petroleum products for our Armed Forces find Wilson Tube Cleaners and accessories invaluable aids in reducing tube cleaning time and trouble, and speeding up production. There is a Wilson Tube Cleaner, cutter-head or other accessory for every refinery tube cleaning need.

Write for the name of our representative nearest to you, or ask for a copy of our new 40-page catalog which fully describes and illustrates the complete line of Wilson tube cleaning equipment.

INVEST IN AMERICA! BUY WAR BONDS AND STAMPS!

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
THE WILSON BUILDING
21-11 44TH AVE. LONG ISLAND CITY, N. Y.



DR. W. S. LANDIS

and the honorary degree of Sc.D. (1922). During 1905 and 1906, he studied mineralogy and crystallography at Heidelberg, Germany, and spent sime time at the Krupp Institute in the Technical High School at Aachen, in 1909. He later taught in the Department of Mineralogy and Metallurgy at Lehigh, resigning as associate professor in 1912 to join the American Cyanamid Company as chief technologist. He has been actively associated with this company ever since. He established its first research laboratory in 1913, was made a director in 1922, and vice president in 1923.

Many patents have been granted to Dr. Landis, and he is the author of numerous articles on chemical, financial, and economic subjects. Throughout his career, he has spent much time and effort towards raising the professional standard of chemists.

Dr. Landis has been chairman of the New York Section of the American Chemical Society, chairman of the New York Section of the Electrochemical Society, president of the national Electrochemical Society, and a member of the Chemist Advisory Council. He is a member of the American Institute of Chemical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Institute of Chemists, president of the Chemists' Club, New York, a trustee of Lehigh University, and a member of the honorary scientific societies, Tau Beta Pi, Sigma Xi, and Epsilon Chi. He has been presented with the Chemical Industry Medal and the Perkins Medal.

Miller Awarded Honorary Degree in Engineering

Walter Miller, vice president of Continental Oil Company, Ponca City, was awarded an honorary degree in engineering by the University of Tulsa May 3. The honor was given in recognition of more than 30 years of service in petroleum refining and especially for his accomplishments in the development of lubricating oils. He was the first man in America to recognize and promote

NICKEL AIDS THE AERONAUTICAL INDUSTRY

to KEEP 'EM FLYING!

The design engineers of the aeronautical industry have repeatedly met demands for improved aircraft to serve on world-wide fighting fronts. At the same time the industry has been able to turn out huge quantities of highly complex precision mechanisms on a mass-production basis.

Since the pioneer days of the aviation industry, it has made extensive use of materials containing Nickel for engine and fuselage parts. In these applications the industry's engineers have developed to the fullest extent the useful and unique properties contributed by Nickel to the materials commonly used in aircraft construction.

The continued widespread use of Nickel reflects confidence based on innumerable satisfactory performance records.

On all fronts, pilots and maintenance crews are learning what metallurgists long have known. Properly used, a little Nickel goes a long way toward assuring the dependable performance of aircraft. From valves to drive gears, and from crankshafts to manifolds, modern aircraft perform more dependably because of the added strength, toughness and resistance to corrosion Nickel imparts to other metals.

The technical staff of International Nickel has been privileged to cooperate with the aeronautical engineers who have accomplished so much toward the improvement of aircraft. These engineers and metallurgists offer counsel and data to all who desire assistance in the selection, fabrication and heat treatment of ferrous and non-ferrous metals.

*** Nickel ***

Send for lists of available publications. Address your inquiries to Technical Library Service

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York, N.Y.

Keep these vital tools ready for action

Suppose an emergency required you to open one of your stills, cracking coils or other tubular units today. Would you be able to take advantage of this condition by cleaning tubes while the unit is down?

How long is it since you looked over your tube cleaners? Why not do it now, while you think of it? They may need adjustment, repair or parts replacement.

You'll have to use your tube cleaners sooner or later, perhaps sooner than you expect. So why risk tying up production on account of imperfect tube cleaners? Get them ready for immediate action now.

The ROTO Company

145 Sussex Avenue

NEWARK, N. J.

ROTO TUBE CLEANERS

WALTER MILLER

the use of synthetic additives in lubricants.

Miller was born in Switzerland and came to the United States when a youth. After completing his elementary education in Elizabeth, New Jersey, he went into the refining plant of Tide Water Oil Company as a yield clerk. He studied chemistry, engineering and accounting at night and came to be process superintendent at the Tide Water plant at Bayonne.

In Oklahoma he was superintendent of Pierce Refining Company, held a similar position with Cosden & Company and in 1931 became a consulting engineer in refining with headquarters at Tulsa. It was in this capacity that he became connected with Marland Oil Company in 1931, and January 1, 1922, he took charge of refining operations of that company. When Marland Oil Company was merged with Continental Oil Company in 1929 he continued as vice president in charge of manufacturing.

Oil and Coal Mixture Now Being Tested

Exhaustive tests to develop a fuel composed of oil and coal have been started by the United States Bureau of Mines and The Atlantic Refining Company at one of its boilers in the Philadelphia refinery.

If the tests prove successful in developing a colloidal fuel for industrial furnaces, heating plants, and power generators, the amount of oil needed by this type of equipment will be reduced by about one third and will be an important factor toward alleviating the serious petroleum shortage along the Atlantic seaboard. It is expected that the tests will be concluded within a month.

Past tests to determine the practicability of a coal-oil fuel have proved inconclusive.

The mixtures used in the experiment contain approximately 60 percent oil and 40 percent bituminous coal pulverized into powdered form in grinding machines.

The Texas Company's policy of many years' standing is to make its patents and inventions available to the petroleum industry at prices that are reasonable.

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TEXACO DEVELOPMENT CORPORATION

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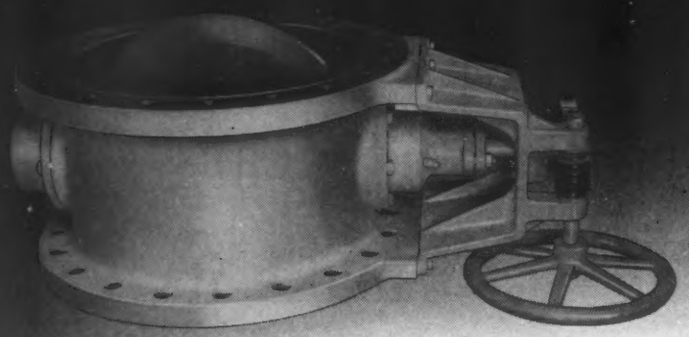
Service Duration Tripled with R-S BUTTERFLY VALVES



125 lb. Butterfly Valve with hand wheel control, American Standard flanges.

150 lb. Class B steel valve with automatic controller.

THE CASE HISTORY of a 6-inch, 125 lb. R-S Butterfly Valve illustrates the advantages and increased service to be obtained from this type valve. It was installed in a line leading to a condenser and used for shut-off under 70 lbs. pressure.

Previous installations of conventional type valves did not hold up and had to be replaced *every six to eight months* as the abrasive action of the fluid in the form of a high pressure "jet" wore a hole through the casing. When an R-S Butterfly Valve with "A" Metal was installed, the length of service was tripled.

R-S QUALITY PRODUCTS SINCE 1904

15 to 900 psi

Here is concrete evidence that even abrasive materials "fan out" into a crescent-shaped spray when the Butterfly Vane approaches a closed position. This fact, coupled with the use of "A" Metal in an R-S Butterfly Valve, produces outstanding results where hard wear and severe stresses are encountered.

The Butterfly Vane is not a "flopper." It is beveled and wedges against the valve body when closed. Compare—results prove the superior efficiency of this type valve under high or low pressures and temperatures.

Your R-S Distributor will gladly furnish detailed information.

VALVE DIVISION

R-S PRODUCTS CORPORATION

120 Berkley Street Philadelphia, Penna.

R-S Streamlined BUTTERFLY VALVES

Continental Announces Changes in Personnel

Continental Oil Company has made the following promotions in the personnel of its manufacturing division:

Charles Morgan, who has been superintendent at the Artesia plant, is now superintendent at the Denver plant. Nolan Horton is superintendent at Artesia and L. W. Vickery is assistant superintendent at the Ponca City refinery.

Morgan had been at Artesia for 14 years previous to the promotion. He started with the organization in 1922 as a stillman at the Glenrock plant.

Horton started with the company as a laboratory tester at the Wichita Falls, Texas, refinery. In August, 1936, he was transferred to the Ponca City plant as an analytical chemist. He was appointed resident chemist at the Artesia refinery in March, 1939, and returned to Ponca City in December, 1942, as a technologist.

L. W. Vickery started his career with the company in November, 1929, as a draftsman in the Ponca City refinery and was transferred to the Baltimore refinery the following year. In 1935, he returned to the Ponca City plant as a technologist and later held the position of foreman and superintendent of the lube oil division.

Military Responsible For Its Fuel Shortage

Tardiness of military authorities in determining requirements of aviation gasoline is responsible for delay in the plant construction program. This testimony was given the Senate committee, headed by Senator Truman by Donald M. Nelson, chairman of the War Production Board. Both the Army and Navy, he pointed out, failed to calculate requirements as long as two years ago. This, rather than diversion of equipment to the synthetic rubber program, is responsible for insufficient fighting-grade aviation fuel as pointed out last month by Robert P. Patterson, Undersecretary of War.

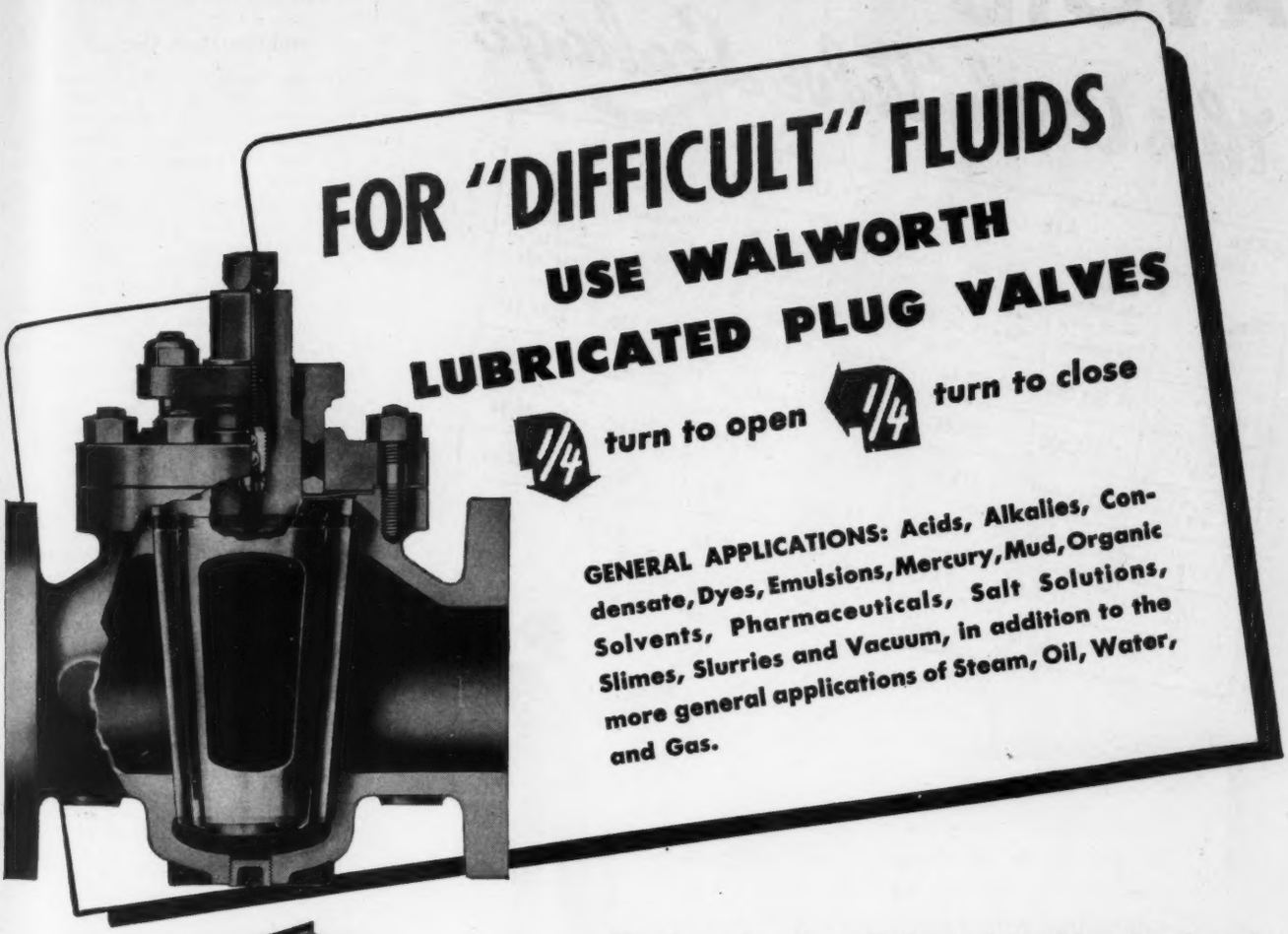
The Senate Committee began its investigation after Patterson and William M. Jeffers, Rubber Director, clashed over apportioning of critical materials. Nelson and Harold L. Ickes, PAW Director, were the first witnesses.

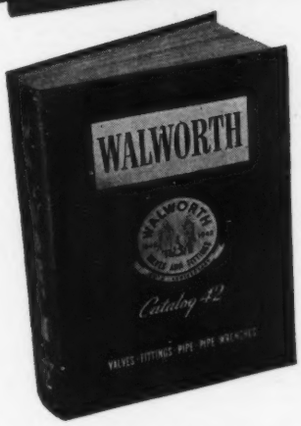
Nelson criticized personal rivalries, classed the demands for material as between rubber and aviation gasoline as the most serious question in the controversy and assured the committee that he would repeat his decision of last winter, if he faced the issue from which the synthetic rubber program was assured equipment for 53 percent of the capacity recommended by the Baruch Committee.

The aviation-gasoline situation arose as early as July, 1940, he disclosed, when the National Defense Advisory Commission recommended creation of a 7,500,000-barrel storage of the fuel.

That suggestion was not carried out because of controversy among military leaders, he testified. The controversy continued into 1941, with the aviation gasoline that might have been stored going into commercial channels. It was not until June, 1942, that the aviation-gasoline program was raised to a high place on the priorities list, he said, explaining that the delay was because the Army "wasn't sure" of its requirements. Both Army and Navy, he said, originally were low on their estimates, although he

FIT THE VALVE TO THE SERVICE


FOR "DIFFICULT" FLUIDS
USE WALWORTH
LUBRICATED PLUG VALVES
1/4 turn to open
1/4 turn to close
GENERAL APPLICATIONS: Acids, Alkalies, Condensate, Dyes, Emulsions, Mercury, Mud, Organic Solvents, Pharmaceuticals, Salt Solutions, Slimes, Slurries and Vacuum, in addition to the more general applications of Steam, Oil, Water, and Gas.



To help you "fit the valve to the service" you'll find pertinent information on Walworth's complete line of valves, fittings, pipe, and pipe wrenches in the new Walworth Catalog 42. Included are 78 pages of practical engineering data that simplify valve selection and make piping layouts easier. Write, on business stationery, for your free copy. Address: Walworth Company, 60 East 42nd Street, New York, N. Y. Department 59.

Here's a valve that will show substantial savings in maintenance and replacement costs on those tough services where the conventional type of valve doesn't stand up.

Walworth Lubricated Plug Valves are of the plug cock type, using insoluble lubricants. Easy operation, tight sealing, and resistance to corrosion and wear are assured by simply turning down the lubricant screw. Pressure, hydraulically exerted on the entire lubricant system, automatically frees the plug from its seat, coats the finished surfaces with a film of protective non-friction lubricant, and seals the ports against leakage.

Although generally an all-purpose valve, Walworth Lubricated Plug Valves are especially adaptable to "difficult" services. Available in sizes from ½ to 24 inches, for pressures from 125 to 5,000 psi, and for all vacuum requirements. They are designed to help you *fit the valve to the service.*

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AVOID this Costly Valve Leakage

AREA OF LEAK	AIR		STEAM		WATER	
Diameter Inches	Number of cubic feet per month at 75 lb. pressure	Total cost of waste per month 11c per 1000 cubic feet	Pounds wasted per month at 160 lb. pressure	Total cost of waste per month 65c per 1000 lb.	Gallons wasted per month at 60 lb. pressure	Total cost of waste per month 16c per 1000 gallons
1/2"	13,468,000	$1,481.44	1,219,280	$792.53	1,524,100	$243.86
3/8"	7,558,500	831.44	684,290	444.79	855,360	136.86
1/4"	3,366,990	370.37	304,820	198.13	381,020	60.96
1/8"	824,570	90.70	74,650	48.52	93,310	14.93
1/16"	213,000	23.43	19,280	12.53	24,110	3.86
1/32"	52,910	5.82	4,790	3.11	5,990	.96

Enlarged copies of this chart on request; also ask for Catalog 78.

Valves aren't easy to replace these days . . . practically all materials going into their manufacture are on the critical list. This means that it is up to every valve user to take the best care of what he has, to insure the longest possible service life.

Leaky valves are saboteurs of your production schedules . . . obstructing your best efforts and increasing your costs. The chart illustrated above gives you an idea of what valve leakage costs you, not to mention the lowered efficiency of your operations.

Fortunately, valves respond to good treatment. Careful handling, immediate repair of the slightest leaks, and prompt replacements of worn parts will keep them on the job, ready to meet the demands imposed by industry's unprecedented war effort.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
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CINCINNATI, OHIO, U. S. A.
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LUNKENHEIMER VALVES

emphasized the military authorities were doing their best to deal with the unknown factors that entered into the situation.

Rubber Most Critical

Nelson declared that the rubber situation was the most critical of all the situations created by the war program, explaining, in response to a question, that the shortage of truck tires "is causing trouble all over the country, and we have had to cut back the military program due to this shortage."

The danger of "rubber bankruptcy" is not over, although the situation has eased, he said, but he suggested that Jeffers be asked to answer questions on the relaxation of rationing regulations.

All of the programs which are competing for the equipment involved in the controversy can be carried out this year, Nelson told the committee.

Declaring that he was proud of his aviation-gasoline program, proud of his PAW experts and proud of the oil industry, Ickes declared that currently more 100-octane than the military agencies asked for is being delivered and that even the greatly increased requirements in June will be met. But, he indicated, from there on it will be a fight.

Not Far-Sighted

Admitting that the military services were not very far-sighted in their estimates of gasoline needs, the administrator said they are now on "our side," but it was not until May, 1942, that any requirements figure, and that semi-official, was procurable as to needs by December, 1943. Even that was based on a then obsolete plane program, and as late as last September there was no official long-range figure available for 1944. PAW made its own calculations, always much higher than the military's estimates, and has consistently been ahead of the services.

"Not Making Too Much"

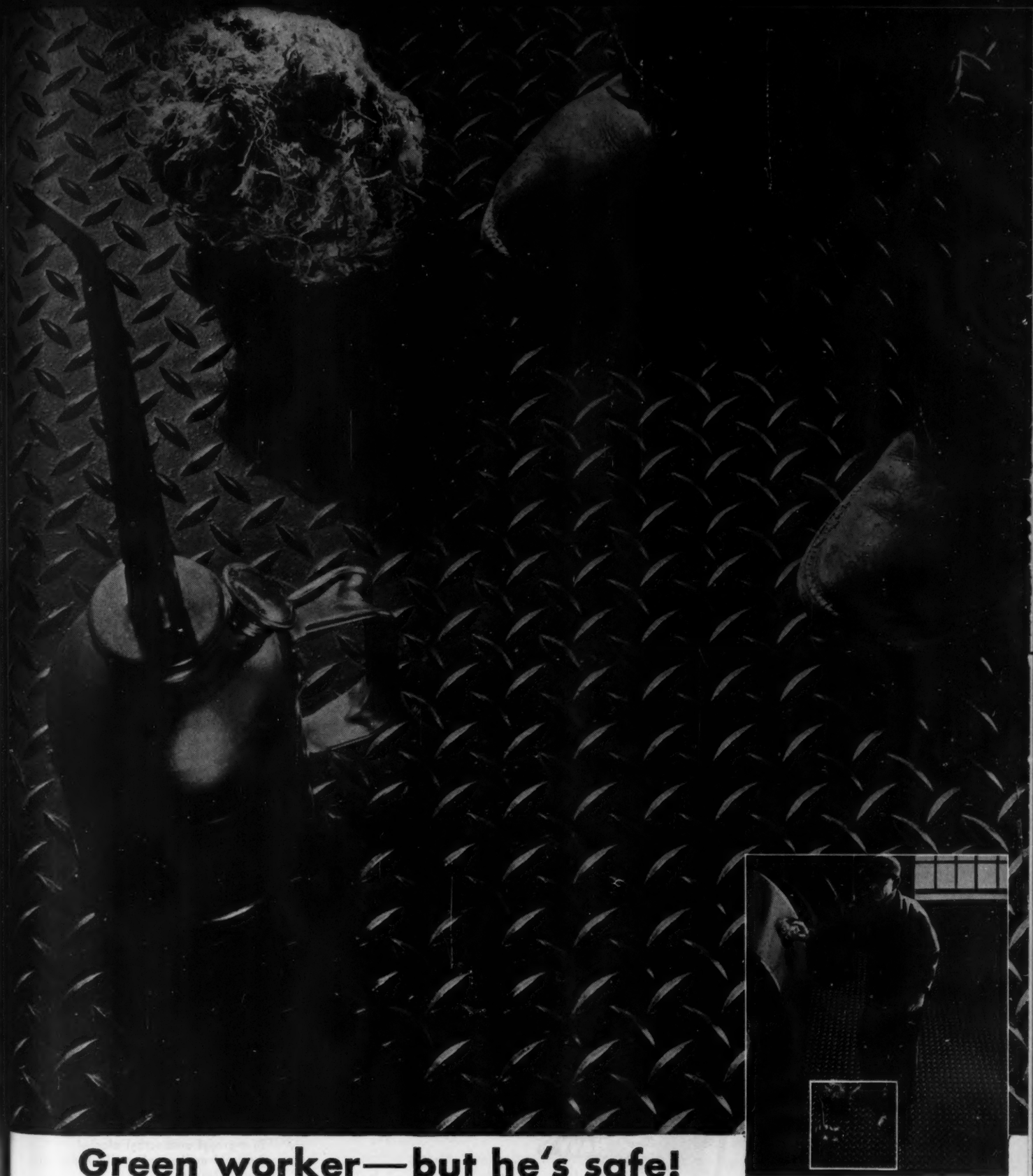
Ickes charged that he made "some 30 separate demands" for help to WPB with little result, until it approved 20 percent of his program last December. On April 19 of this year, he said, it acted to schedule construction of the remaining plants in the program—an order which should have been issued in January or February so that the shops would be prepared for it.

"We are not making as much 100-octane as we wish we were making," he told the committee. "We are not making as much as we need."

Asked by Senator Truman whether the several war agency heads consulted each other on mutual problems and whether there was any cooperation among them, Ickes said there were few moves in that direction. "I am the best cooperator in Washington—when I can have my own way," he volunteered.

SONJ Offers Buna-S Patents to Government

Standard Oil Company (New Jersey) has offered all its patents in Buna-S rubber to the federal government through Rubber Reserve Corporation. Under the proposal the government would have title to all patents for their life, with free license for itself and the privilege of granting royalty-free licenses to anyone who cooperates in the program of synthetic-rubber production



Green worker—but he's safe!

He's a new man in a vital war plant . . . working long hours . . . sometimes forgetting to be careful. Here is a real job for "A.W." Rolled Steel Floor Plate—to stop the alarming increase in slipping and falling accidents, to end floor troubles for good. "A.W." Floor Plate protects men essential in the war effort wherever they may be. Fire-proof, heat-proof, oil-proof, crack-proof. Write for folder.

Other products include Plates, Sheets, Billets, Blooms, Slabs—Carbon, Copper or Alloy analyses.

ALAN WOOD STEEL COMPANY

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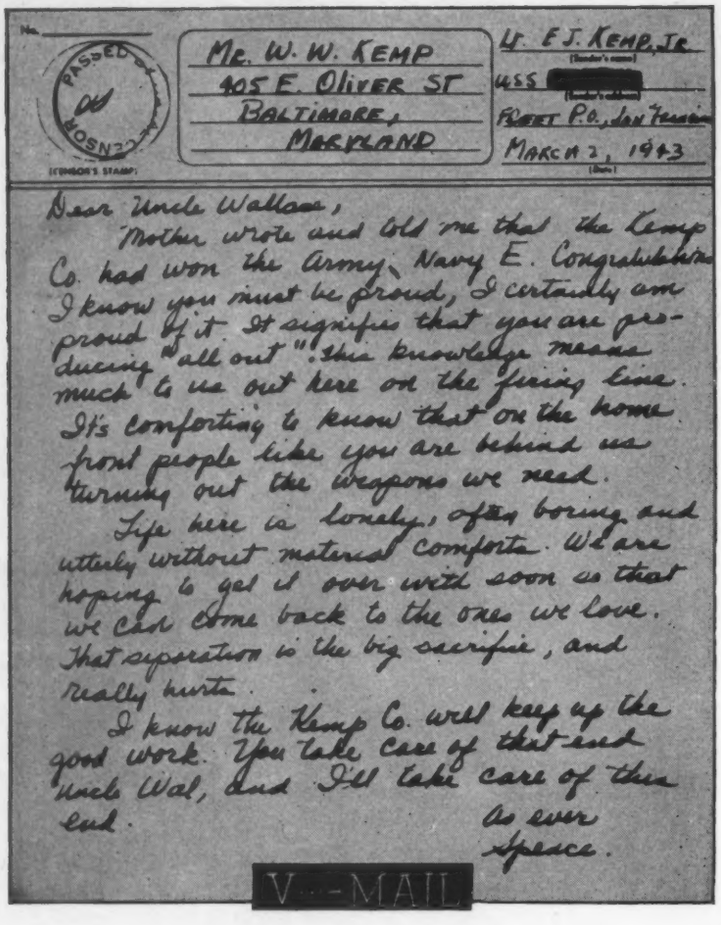
FRIENDS OF KEMP, both old and new, will be interested in this V Mail from the Front Line:



Mr. W. W. KEMP
405 E. OLIVER ST
BALTIMORE,
MARYLAND

Lt. E. J. KEMP, Jr.
USS [redacted]
FLEET P.O., San Francisco
MARCH 2, 1943

Dear Uncle Wallace,
Mother wrote and told me that the Kemp Co. had won the Army, Navy E. Congratulations. I know you must be proud, I certainly am proud of it. It signifies that you are producing "all out". This knowledge means much to us out here on the firing line. It's comforting to know that on the home front people like you are behind us turning out the weapons we need.
Life here is lonely, often boring and utterly without material comforts. We are hoping to get it over with soon so that we can come back to the ones we love. That separation is the big sacrifice, and really hurts.
I know the Kemp Co. will keep up the good work. You take care of that end Uncle Wal, and I'll take care of this end.
As ever
Spence.

V-MAIL

The Army-Navy "E" flag, awarded "for high achievement in the production of materials of war," proudly flies at The C. M. Kemp Mfg. Co.

KEMP of BALTIMORE

and reciprocates with similar licenses under its own patents.

In offering the patents a statement by the corporation was that it was being done "in order to give the greatest possible impetus to the wartime rubber program."

Objectives set forth were:

To give every possible incentive to cooperation in the war rubber program.

To remove concern about post-war patent situation from any who may have a contribution to make.

To encourage American research and ingenuity to build a new industry.

To continue to do everything it can to assure tires for America's cars always.

The government would provide an additional $5,000,000 for research as part of the agreement.

In replying to the offer, William M. Jeffers, Rubber Director, said:

"Your proposal is very definitely in the public interest and this is an eminently propitious time to make the offer. I hope that your example will lead others to join promptly in this effort."

Hydrocarbon Book Is Being Revised

A fourth edition of *Physical Constants of the Principal Hydrocarbons*, by M. P. Doss, has been suggested by the Technical Advisory Committee of the Petroleum Industry War Council, and will be published by The Texas Company if sufficient advance orders for copies are received.

The third edition, issued in March, 1942, contained 215 pages and listed the properties of more than 2,000 hydrocarbons. In the proposed new edition, scheduled to appear about May 20, more than 100 pages will be revised to include new or corrected data, particularly on hydrocarbons related to the manufacture of aviation gasoline, synthetic rubber, synthetic resins, and toluene.

The book will be available at cost—approximately $5.00 a copy. Requests for copies may be addressed to M. P. Doss, The Texas Company, 135 East 42nd Street, New York.

RARE CHEMICALS

THE National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only in one-gram quantities, please inform the registry.

Alpha-methyl-vinyl-methyl-ketone.
Alpha-amino-valeric acid.
Delta-amino-valeric acid.
Di-n-propyl aminoethyl alcohol.
2-nitro-4-methoxy benzaldehyde (nitro anisaldehyde).
O-nitrophenyl acetic acid.
O-nitro-p-methoxy phenyl acetic acid.
Ethylene disulphonate.
2-amino-heptane sulphate.
Chloroethylmethylether.
Decyl-, hexadecyl-, octadecyl-, and heptacosyl isocyanate.
Cyclobutanone.
Naphthylhydrazine hydro-chloride.
Octene.
Isobutyl-p-aminophenol.
4:4¹ diamidino diphenoxy pentane.
4:4¹ diamidino diphenoxy propane.

No. 4: Tips on Condenser Tube Maintenance

Simple methods of repairing and reworking worn tubes

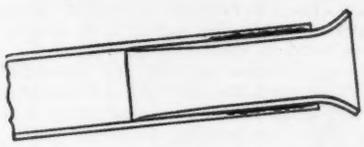
Most of the causes of condenser tube damage can be eliminated . . . and even where damage has occurred, many tubes can be repaired and put back into useful service, thereby conserving copper and other critical war materials.

The chief causes of trouble are: 1. Excessive local turbulence; 2. Finely divided air bubbles; 3. Excessive solids in the cooling water. Methods of preventing these have been discussed in previous messages in this series and further information will be supplied on request.

The following suggest several practical methods of overcoming certain types of damage to tubes, which can be easily applied under today's conditions.

The use of sleeves for pitted inlet ends

When tubes begin to show signs of pitting on inlet ends, the usual practice is to set flared sleeves in the



tubes. These sleeves should be carefully made to fit tightly and leave no shoulder at the inside end which might cause turbulence.

Where the ferrules have been destroyed

In some cases, the tubes may have failed only at the inlet end, with very little corrosion elsewhere. However the ferrules may have been destroyed. In this situation, the bad ends may be cut off, the tubes then stretched and used again.

Changing the location of tubes

When tubes begin to leak because of pitting or plug-type dezincification, and replacement seems indicated, many tubes may still be in good enough condition for further use. All the tubes can be withdrawn and carefully tested. The poorest can be discarded and those passing the test can be re-used. Longer service will follow if these re-used tubes are placed in that part of the condenser where the least corrosion has occurred.

We will be glad to send you further information on methods of prolonging condenser tube life if you will mail your request on a letterhead to the address below. 4304

THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Conn.
Subsidiary of Anaconda Copper Mining Co.
In Canada:
Anaconda American Brass Ltd., *New Toronto, Ont.*

ANACONDA

Anaconda Condenser Tubes

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

PETROLEUM REFINER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical And Chemical Data

The Physical Properties of Alicyclic Hydrocarbons. II. Boiling Points of Monocyclic Hydrocarbons. G. EGLOFF AND R. C. KUDER, *J. Phys. Chem.* **46** (1942) pp. 934-45.

The authors studied the boiling point data for more than 300 hydrocarbons and reached certain generalizations on the relationships between boiling point and structure. The unsubstituted monocyclic saturated hydrocarbons from C_3 to C_{10}, have boiling points from 9° to 27° C. higher than the corresponding normal alkanes and 15° to 30° higher than the isomeric 1-alkenes. Branching of side chains lowers boiling points, as it does among the alkanes. Among the isomeric compounds of given alicyclic content the boiling point generally decreases as the number of aliphatic side chains increases. Among the isomeric dialkylcyclanes, 1,1-substitution gives the lowest boiling point and 1,2-substitution gives the highest, even when the substitution groups are not the same. Among 20 sets of cis-trans isomers the boiling points of the cis compounds were from 0° to 7.5° higher than those of the trans compounds. A discussion of the effect of double bonds is included. The Boord classification of double-bond types was used. The introduction of a triple bond into a saturated alicyclic hydrocarbon raises its boiling point.

Properties of Normal Paraffins. L. IVANOVSZKY AND A. V. BRANCKER, *Petroleum* (London) **5** (1942) pp. 168-73, 188-90.

The authors report studies that indicate that the melting point of paraffin hydrocarbon mixtures is essentially additive if the hydrocarbons do not differ by more than 2 carbon atoms. If the melting point is plotted against molecular weight, 2 smooth curves are found, one for odd and one for even numbered hydrocarbons. These curves converge at the molecular weight of about C_{22}. The various formulations that express this relationship are considered. Curves representing the Ivanovszky and Ivanovszky-Brancker formulas expressing the relationship between melting point and molecular weight indicate that the melting points of normal paraffins tend to approach a limit at about 405° K. At this temperature a difference of 4000 carbon atoms causes a change of only about 2° K. in melting point.

The Heat Capacity and Entropy, Heats of Transition, Fusion and Vaporization and the Vapor Pressures of Cyclopentane. Evidence for a Non-Planar Structure, J. G. ASTON, H. L. FINK AND S. C. SCHUMANN, *Jour. Amer. Chem. Soc.* **65** (1943) pp. 341-6.

The heat capacity of solid and liquid cyclopentane was measured from 11.8° to 293.82° K. The equilibrium temperatures of the lower transition, the upper transition and the fusion, together with their heats were determined. The heat of vaporization was determined at 298.16° K. The experimental vapor pressure equation over the range 220° to 287° K. was used to calculate values of the heat of vaporization at 230°, 260°, and 298.16° K. Comparisons of the experimental entropy with that calculated from statistical and molecular data at 230° and 298.16° K. indicate a symmetry number of one and that the cyclopentane ring is non-planar, one carbon atom being out of the plane. This effect is attributed to the hydrogen interactions of the type hindering internal rotation which must therefore be repulsions. The methods and apparatus used are briefly described. Data are presented in detail in tabular and graphical form.

Molecular Weights and Intrinsic Viscosities of Polyisobutylenes, P. J. FLORY, *Jour. Amer. Chem. Soc.* **65** (1943) pp. 372-82.

One of the most important phases of high polymer chemistry is the assignment of molecular weight values to these substances. In the present investigation intrinsic viscosities of carefully fractionated polyisobutylene were compared with their absolute number average molecular weight determined by an osmotic pressure method. Experimental methods for fractionating polyisobutylene and for determining osmotic pressures are described. The ratio π/c of osmotic pressure to concentration has been found in the case of cyclohexane solutions of polyisobutylene to vary non-linearly with concentration, contrary to recent theories advanced by Huggins and Flory. The slope of this relationship appears independent of molecular weight. Reliable methods for extrapolating π/c to $c = 0$ were established, enabling the determination of absolute molecular weights with satisfactory precision up to values of about 1,000,000. Molecular weights of polyisobutylenes calculated from Staudinger's equation are too low; the discrepancy is more than ten-fold at high molecular weights. On the basis of data for carefully fractionated samples covering a two-hundred-fold molecular weight range, the intrinsic viscosity is found to be proportional to the 0.64 power of the molecular weight. This decided deviation from Staudinger's so-called "law" cannot in this instance be attributed to non-linear chain structure, as Staudinger has sought to do in other cases. This dependence of molecular weight on intrinsic viscosity leads to the definition of a "viscosity average molecular weight which is obtained when the relationship is applied to heterogeneous polymers. The viscosity average is less than the weight average molecular weight, which would be obtained if Staudinger's equation were applicable, and greater than the number average obtained by osmotic or cryoscopic methods.

Chemical Compositions And Reactions

Polyisopropylbenzenes. I. Preparation and Properties of Two Di-, Two Tri-, and One Tetra-Isopropylbenzene, A. NEWTON, *Jour. Amer. Chem. Soc.* **65** (1943) pp. 320-3.

Although much attention has been paid to various catalytic methods of introducing isopropyl groups into the benzene ring, comparatively little has been reported on the composition of the products. The composition of the di, tri- and tetra-isopropylbenzene fractions, obtained by the action of propene on benzene in the presence of sulfuric acid or aluminum chloride, was determined. In the presence of aluminum chloride, 1,2,4-triisopropylbenzene is converted to the 1,3,5-isomer with simultaneous formation of higher and lower homologs. Two di, two tri- and one tetra-isopropylbenzene were isolated in a high state of purity and their physical properties were determined. The experimental procedures used are described in some detail, and the data

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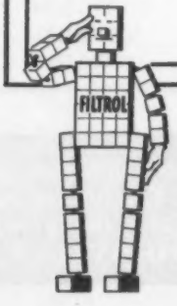

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are presented in tabular and graphical form.

Catalytic Alkylation of Benzene with Ethylene, W. A. PARDEE AND B. F. DODGE, *Ind. & Eng. Chem.* **35** (1943) pp. 273-8.

The development of the uses of styrene over the past few years in the manufacture of resins and synthetic rubber has increased interest in processes by which it can be synthesized. When dehydrogenated, monoethylbenzene produces styrene, and the most important processes in operation at this time for the manufacture of styrene involve monoethylbenzene as the starting material. Large producers of ethylbenzene use an agitated liquid phase for contacting benzene with ethylene in the presence of a metal halide catalyst, such as aluminum chloride. The investigation reported in the article is concerned with the reaction of ethylene with benzene in the vapor phase, utilizing an apparatus in which the mixed vapors of ethylene and benzene pass through a catalyst bed in which the reaction takes place. The reaction between ethylene and benzene vapors at pressures up to 200 pounds per square inch gage, temperature range 230-270° C., and at space velocities of 11 to 50 cc. per hour per cc. of catalyst were studied in a flowing system under the influence of eleven different catalysts. Sodium chloride-aluminum chloride - pumice and phosphoric acid-kieselguhr were the only catalysts giving detectable reactions. Mono- and diethylbenzenes were identified in the liquid products. The former catalysts under some conditions converted as much as 95 percent of the ethylene to ethylbenzenes. A series of runs was made to determine the effect of time, pressure, and space velocity on the reaction when the sodium chloride-aluminum chloride-pumice catalyst was used. The catalyst was found to have a very short life, the ethylene conversion decreased from 93 to 75 percent over a period necessary for the conversion of 0 to 1.16 gram mole of ethylene to ethylbenzenes. Pressure had a surprising influence on the reaction. At atmospheric pressure there was no detectable conversion, while at 200 pounds gage pressure as much as 95 percent of the ethylene was converted to ethylbenzenes. The effect of space velocity on the conversion was negligible over the range of about 11 to 50 cc. per hour per cc. of catalyst. The apparatus used is described, the various catalysts used are listed and briefly described, the data are presented in some detail in tabular and graphical form, and a bibliography of twenty-four references is appended.

Alkylated Cresols from Refinery Gases, W. WEINRICH, *Ind. & Eng. Chem.* **35** (1943) pp. 264-72.

The search for more efficient antioxidants for petroleum fractions has led many investigators to consider the alkylated phenols. The general reaction between phenols and olefins has been known for a considerable time. Many earlier investigators made and identified monoalkyl and dialkyl phenols which, in contrast to most of the trialkyl derivatives, are soluble in dilute caustic soda solution. Not until about ten years ago, however, was a systematic study started on the reactions

. . . an alternate may become a standard

For over 25 years the steel industry has used palm oil, from Africa and the Far East, to counteract friction in certain cold rolling operations. Now . . . . palm oil is encountering difficulty in getting to work. But, as has happened so many times during the war, an alternate has been found in the petroleum industry—an alternate so satisfactory that it shows promise of replacing the original. Thus another contribution is added to the long list of petroleum developments for America's "arsenal of democracy" program.

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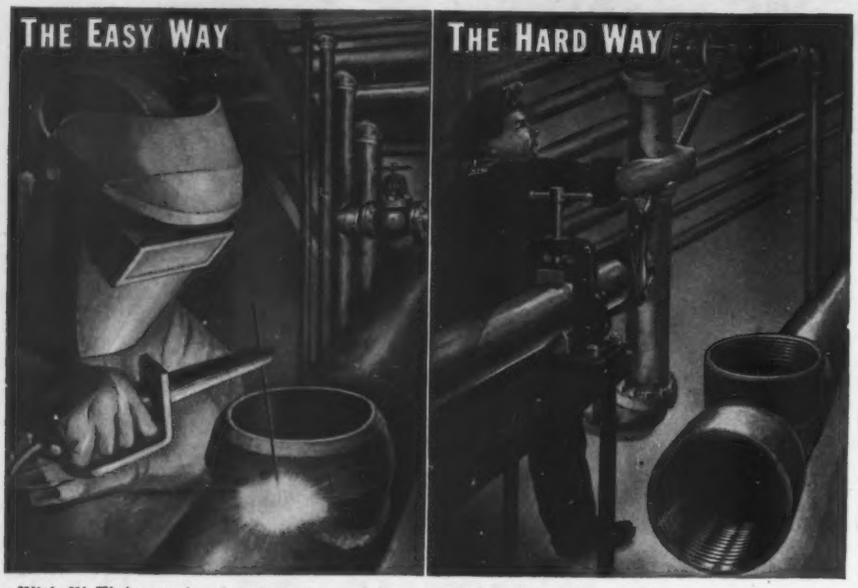

With W-T's* you simply select the position of the outlet on the main pipe and weld the fitting into place, either before or after erection of the main line. The hole is usually cut in the main pipe with the torch after the fitting is installed.

Old-fashioned methods of cutting, forming and fitting the main pipe for installation of a tee are eliminated with W-T's*—saving time and money. W-T's* provide a simple, fast, economical way to make right-angle, welded branch pipe outlets.

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Installed with electric-arc or oxy-acetylene method by any welder of average ability.

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Beveled outlet of WELDOLETS permits branch pipe to be attached with plain, circumferential, butt weld.

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and reaction conditions leading to the formation of trialkylated phenols. From the work done in this period has emerged a new class of organic chemicals, the trialkylated phenols, that are finding an ever-widening scope of usefulness. Phenols react selectively with the isobutylene contained in refinery butane-butene fractions in the presence of catalytic amounts of concentrated sulfuric acid to form the corresponding tertiary-butyl derivatives. Conditions have been determined for the synthesis of 2,6-di-tert-butyl-4-methylphenol and of 4,6-di-tert-butyl-3-methylphenol from a commercial m-p-cresol cut of coal tar acids, and continuous separation of the dibutyl cresols by distillation. The early pilot plant work on this problem is briefly reviewed and followed by a more complete description of a small commercial plant for the manufacture of the tertiary-butyl derivatives of m- and p-cresol. The presence of minor proportions of o-cresol and of low-boiling xylenols in the cresol cut charged to the process introduces certain purification problems that are discussed in the light of the properties of the alkylated phenols involved. A flowsheet showing an alkylation and distillation system for a semi-commercial plant is included. The physical properties of the cresols, xylenols, and tertiary butyl derivatives are tabulated.

Ketone Synthesis, A. C. BYRNS AND T. F. DOUMANI, *Ind. & Eng. Chem.* 35 (1943) pp. 349-53.

A synthesis of unsaturated methyl ketones by reaction of branched-chain olefins with acetic anhydride is given. Zinc chloride and sulfuric acid were found to be effective condensing agents; optimum yields of ketones are obtained with less than one mole of condensing agent per mole of reactants. The methyl octenyl ketone obtained as the principal product from diisobutylene has been shown by ozonolysis to be 4,6,6-trimethyl-3-heptane-2-one. Polymer gasoline, obtained from cracking-plant gases by polymerization with solid phosphoric acid, has been shown to be a suitable source of olefins. A pilot plant used for the synthesis of ketones is described. The heat of reaction when one mole of diisobutylene is reacted with one mole of acetic anhydride in the presence of 0.5 mole of zinc chloride at 36-37° C. was found to be 8800 calories. A number of interesting possibilities for the utilization of new derivatives of this ketone type exist. Because of their pleasant odor they may be useful in the production of the cheaper grades of perfumes, particularly those used in industrial products. They are of interest as high-boiling solvents. A number of derivatives such as methyl octyl ketone, methyl octyl carbinol, and the esters of the carbinol have been prepared. They have characteristics odors that are also of interest in perfumes.

Manufacture: Processes and Plant

Introduction to Chemical Thermodynamics, LUKE E. STEINER, McGraw-Hill Book Co., Inc., New York, 1941, vii. +516 pp. Price, $4.00.

The book is designed as a textbook for college seniors and first-year graduate students having no previous knowledge of thermodynamics. The author's objectives are to acquaint the reader

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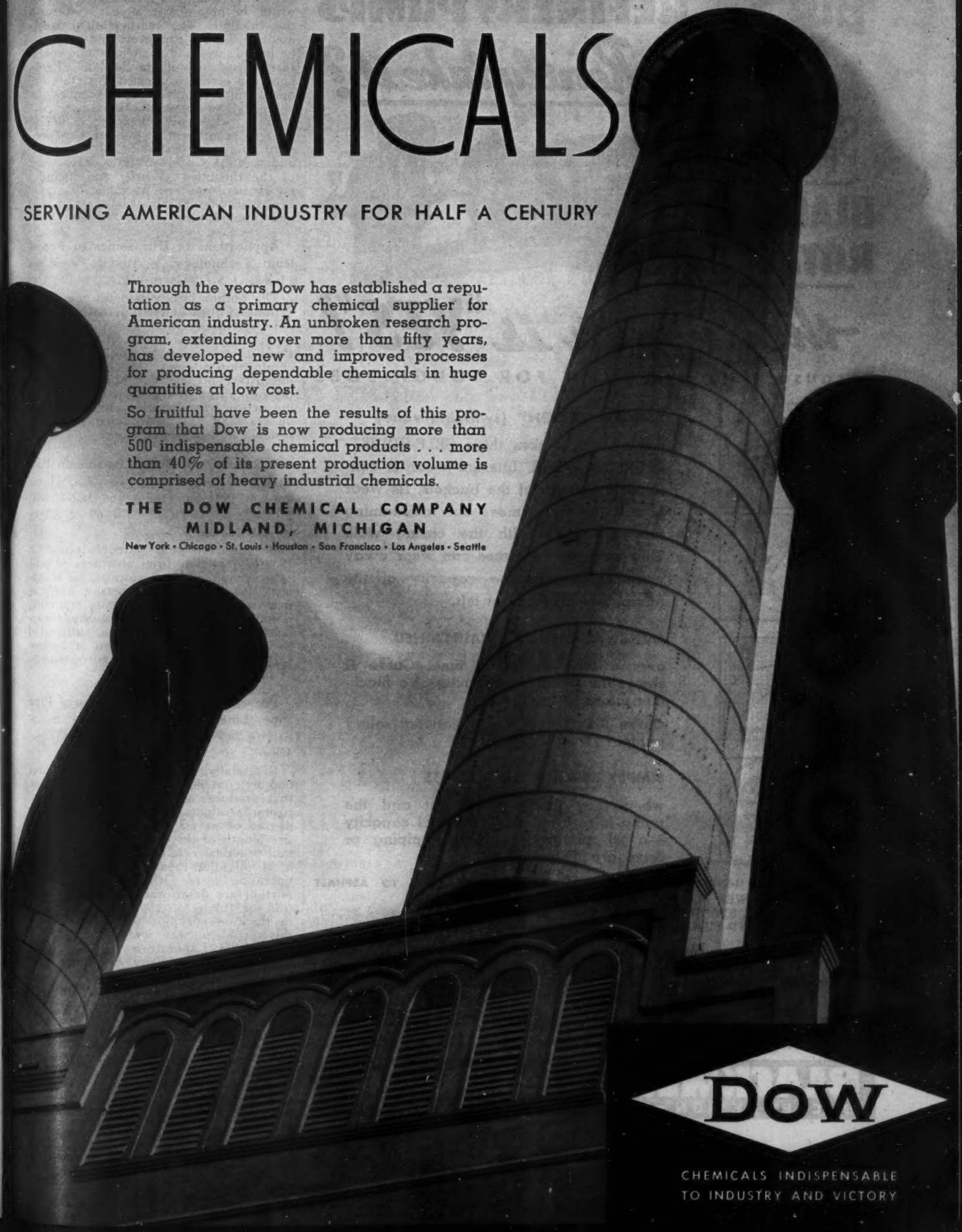

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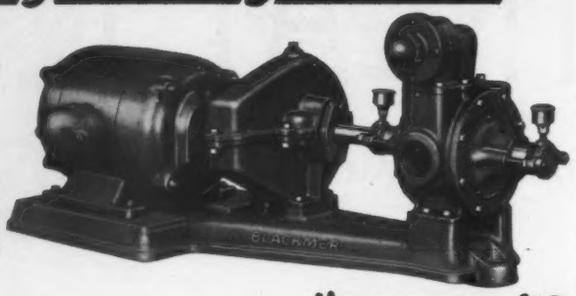

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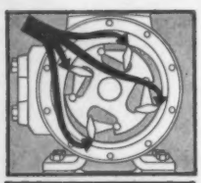
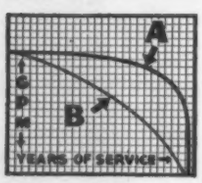


"BUCKET DESIGN" (swinging vane)

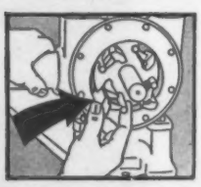
construction makes them SELF-ADJUSTING FOR WEAR. Internal wear is confined to the tips of the buckets. As wear occurs, the vanes move out, maintaining proper contact with the casing wall. This much of the vanes can wear away without affecting the capacity of the pump. See sketches at left.



ORIGINAL CAPACITY MAINTAINED

over a long period of time. Curve A shows the sustained capacity of a Blackmer pump.

Curve B indicates a conventional rotary pump.



SIMPLY REPLACE THE BUCKETS

when they finally wear out and the pump is restored to its original capacity —a 20 minute job. Neither piping or drive are disturbed.

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"BUCKET DESIGN"—SELF-ADJUSTING FOR WEAR

with the fundamental theories of thermodynamics and to train him in the use of tables and thermodynamic data in the current literature, and to provide him with a proper basis for future study in the field. The text assumes no knowledge of mathematics beyond what would be obtained in a year's study of the calculus. The mathematical treatment in the book is direct and extremely full. Lewis and Randall's nomenclature is used throughout the book. Problems are given to afford the student an opportunity to apply the principles developed. The customary topics are covered in twenty-one chapters, including general equilibrium conditions, non-ideal solutions, partial molal quantities, and solutions of electrolytes. Treatment of the third law is brief and includes no discussion of spectroscopic or statistical methods. The book is well printed and typographical errors are few.

Applications of Ultrasonics to Petroleum Technology, V. BISKE, *Petroleum* (London) **5** (1942) p. 125.

The author briefly reviews the applications of ultrasonics to petroleum technology. Among these are: the preparation of stable water-in-oil fuel emulsions to improve carburation in internal-combustion engines, the coagulation of impurities present in lubricating oils, the promotion of the asphaltene-removing action of sulphuric acid, and effect on cracking and hydrogenation of petroleum hydrocarbons.

A Summary of British Petroleum Patents, 1939-1941 Anon., *Petroleum* (London) **4** (1941) pp. 162-4, 166, 182-4, 188; **5** (1942) pp. 18-20, 22, 51-4, 69-72, 88-90, 107-10, 128-30, 174-6.

British petroleum patents issued in 1939-1941 include brief abstracts of patents dealing with oil storage, oil transport, lubricating oils, greases, application of lubricants, distillation, cracking, refining, wax, halogenated hydrocarbons, nitrated hydrocarbons, sulfonated hydrocarbons, hydrogenation of hydrocarbons, and destructive hydrogenation of carbonaceous materials.

Preventing Internal Corrosion of Pipe Pipe Lines, A. WACHTER AND S. S. SMITH, *Ind. & Eng. Chem.* **35** (1943) pp. 358-67.

Practically every long pipe line has had to contend with internal corrosion that produces scale and blisters of corrosion products, extending with some degree of severity throughout the entire length of the steel line. The important practical results have been decrease of throughput capacity and increase of operating costs. Other results less important are deterioration or contamination of the refined products and loss in thickness of pipe wall. A study of this problem was undertaken at the Emeryville Laboratories of the Shell Development Company. Sodium nitrite was found to be especially suitable for the prevention of internal corrosion by water and oxygen in steel pipe lines for refined petroleum products. It is effective in low concentrations in preventing corrosion on clean mill-scale-covered and on rusted steel surfaces under gasoline pipe line conditions; it tends to aid in the removal of pre-existing rust scale and blisters. No adverse effects have been found on the quality of refined

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Plants right here in the U.S.A.—that's where the rubber is coming from that we must have to win the war The first of several plants is already in operation

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The expense of upkeep is more important than the original cost of a pump, as any refinery operator knows. This is especially true now, when replacement parts are a drain on the nation's stock pile of metals, and manpower to install replacements is often lacking.

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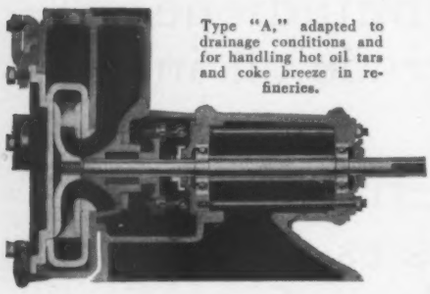
Consider, for example, the basic soundness of having the water-end and the base or bearing



Type "A," adapted to drainage conditions and for handling hot oil tars and coke breeze in refineries.

stand two separate units instead of having the pump shell bolted to the base. Users tell us the advantage of ready removal of the water-end unit is a real one, particularly in the time saved by not having to dismantle the entire pump.

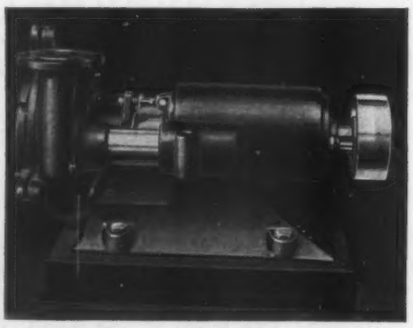
Likewise observe the accessibility of the impeller. Note that the side plate on the Amsco-Nagle pump can be quickly removed by merely loosening three to five clamp bolts, depending on pump size. Adjustment of the stuffing box gland is a very simple procedure. No special tools are needed.

Intake, outlet and impeller are streamlined to reduce frictional losses.

A variety of impellers is made, each type suitable for a given set of pumping conditions, the proper choice naturally effecting the greatest hydraulic efficiency of which the pump is capable.

Even with sound design, the use of unsuitable materials can increase the cost of upkeep. Besides Amsco's broad experience in producing shock and abrasion resistant manganese steel and heat and corrosion resistant alloy castings, other Brake Shoe divisions make other ferrous and non-ferrous castings so that we can supply from our own plants almost any metal required for water-ends.

The complete story of this unusual line of pumps is given in Bulletin 940, sent on request. Vertical shaft pumps, with features typical of all Amsco-Nagle pumps, are also described.



Type "T," for operation under flooded conditions or where priming is no obstacle. Note the readily removed water-end.

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products moved through a line treated with nitrite. Sodium nitrite has been successfully used for the inhibition of internal corrosion in more than 800 miles of pipe lines for refined oil products. The use of mechanical scraping measures for the removal of old rust scale while injecting sodium nitrite continuously into a pipe line has been shown to achieve a clean nonrusting pipe line with a flow factor significantly higher than the design value usually taken for new pipe. The data obtained in the course of the work are presented in considerable detail in tabular form. A bibliography of twenty-three references is included.

Acid Pump Problems Involving Long Suction Lines, W. E. PRATT, *Chem. & Met. Engr.* **50** (1943) pp. 104-7.

This is the third of a series of articles on installation and operation of acid pumps. It deals with the decrease in performance of a pump figured on the basis of water when handling a viscous liquid, such as cold, concentrated sulphuric acid, and shows by an actual example how such a pump can cease functioning entirely if the suction line resistance is too high. It is true that today an installation for pumping viscous oils is usually just as carefully engineered as a common water pumping plant, and the results can be predicted just as accurately. Relatively little is known, however, about the performance of most chemical pumps when they are used for pumping heavy, viscous liquids, such as cold, concentrated sulphuric acid. Charts are included in the article showing head capacity and friction system curves for water and acid, and showing typical capacity decrease and power increase when handling a viscous liquid, and also variation of performance with viscosity in a typical 2-inch closed-impeller pump of the type used for handling strong sulphuric acid.

Products: Properties And Utilization

Fluid Filling Media for Electrical Apparatus, F. MEYER, *G. E. C. Journal* **11** (1941) pp. 210-17.

The oils used for filling transformers and switch gears were studied. The author does not regard the Michie sludge test as a useful guide for the selection of a transformer oil. It is held that in bringing down the sludge value to a low limit the danger of increasing the acidity grows and this is as harmful as a high sludge value. A lesser degree of refinement would be satisfactory if the acidity were kept low. Observations are reported showing that transformer oils produce corrosive effects after use. This is caused by the formation of acetic acid in the oil. The oil acidity is found to be very much greater after a period of use than when fresh. Experiments covering a period of six months are reported. In these the development of acidity in service under service conditions was determined. The effect of the acid formed on varnished and unvarnished coils immersed in the oil was studied. The difference in acidity from different makes of oil and different grades of oil was investigated. Grade "A" oils showed an acceleration in the rate of acid formation after 3 months of continuous use, and this increased steadily. Grade "B" oils showed a slower and regular rise of acid formation,

call CORBETT-WALLACE for:

TAYLOR Seamless Steel Welding Fittings, Seamless Steel Nozzles, Forged Steel Flanges • GLOBE Seamless Steel Boiler, Condenser and Still Tubes • YOUNGSTOWN Seamless Steel Butt-weld and Lap-weld Pipe • PETRO & MARK Forged Steel Unions • JENKINS Valves • LAMSON & SESSIONS Bolts, Nuts and Rivets • WORTH Steel Plates and Heads for Mill Shipments Only • CROSS Perforated Plates and Sheets.

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Quality Products Plus Engineering Assistance

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MECHANICAL ENGINEER

with experience in petroleum and natural gas industries

Want mechanical engineer who is experienced in process equipment used in the petroleum and natural gas industries, and who knows design and specification of towers, heat exchangers, pumps, instruments, etc.

Good salary, permanent position, excellent future. Give full details of experience, education, personal data. Address:

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THE GIRDLER CORPORATION

Gas Processes Division

224 E. BROADWAY LOUISVILLE, KY.

Do You Realize...

★ THAT 100' OF PIPE EXPANDS 5.1" DURING A TEMPERATURE CHANGE OF 0° TO 600°

★ THAT YOU *CAN'T* PREVENT IT . . .

★ THAT YOU *MUST* PROVIDE FOR IT

Unless proper provision is made for expansion caused by temperature changes, walls may be pushed out, pipes buckled—apparatus, pipes and fittings broken. With high pressure steam, this may not only be expensive but may stop production.

Eliminate these dangers by installing Adsco Expansion Joints. In addition to the Adsco Piston-Ring Joint described below, there are other Adsco joints for both high and low pressures and temperatures — internally guided — internally-externally guided — with or without drip connections, service outlets, or base.

Describe your piping problem and we will be glad to make expansion joint recommendations. Write for Catalog No. 35R.

AMERICAN DISTRICT STEAM COMPANY

N. TONAWANDA, N. Y.

MAKING "UP-TO-DATE" STEAM LINE EQUIPMENT FOR OVER 60 YEARS.

CONTROL HIGH PRESSURE, PIPE EXPANSION WITH ADSCO PISTON-RING EXPANSION JOINT . . .

The only slip type joint that can be packed and repacked under full operating pressure. No need to shut the plant down or cut a pipe out of service.

Piston rings in the internal guide hold the line pressure during packing and repacking. Fully guided by internal and external guide. Available in single or double joints, flanged or beveled ends.

ADSCO
EXPANSION JOINTS
ELIMINATE CUMBERSOME PIPE BENDS

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Offered in
Series of Technical Bulletins

Goetze Gasket Research has developed hitherto unknown gasket data through the duplication of actual service conditions in their modern laboratory.

This information is being issued in a series of technical bulletins available to interested engineers and designers of pressure equipment.

If you wish to receive these bulletins regularly, write on your company letterhead, giving your position.

GOETZE GASKET & PACKING CO., Inc.
65 Allen Ave., New Brunswick, N.J.

Goetze for GASKETS
"America's Oldest and Largest Industrial Gasket Manufacturer"

UNRETOUCHED PHOTOGRAPH OF
SCALE DEPOSIT
IN 12-INCH STEAM LINE

The picture of this scale deposit was taken from a point in the header 400 feet from the boilers. This scale seriously impaired the efficiency of this plant.

The solution to this problem is Haering Glucosates which remove the scale and protect pipe lines from further scale and corrosion.

WE READ WATER

SEND FOR INFORMATION

D. W. HAERING & CO., Inc.
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D. W. HAERING & CO., INC.
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Please send me free booklet on Water Treating in Refineries. (P.R.)

Name_____

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City_____ State_____

the rate decreasing after 5 months. The immersion of varnished coils in "A" oils increased the acidity, but with unvarnished coils more volatile acids are produced. Varnished coils immersed in "B" oils lead to the formation of less acidity and there is substantially no volatile acid formation. The difference in acidity developed in the two grades of oil was most marked, the "B" grade always showing less. The author considers acidity of greater importance than sludge value as a criterion for transformer oils, and advises that the value should be included in the specification of these oils. The development of acidity is influenced by the nature of the crude oil, the method of treatment adopted for the production of the basic distillate, the method of refining used, and the degree of refining achieved. Other materials, such as chlorinated compounds, were studied. Oils for impregnating condensers were discussed. Experiments are described on the absorption of hydrogen gas by oils subject to electrical stresses. The relationship between iodine value and the absorption or evolution of hydrogen is considered. Precautions to be observed with oils of either high or low iodine value are discussed. Methods of reconditioning the oils are described.

The Rolling Ball Viscometer, R. M. HUBBARD AND G. G. BROWN, *Ind. & Eng. Chem., Anal. Ed.* **15** (1943) pp. 212-18.

A study of the system of the inclined tube and rolling ball as applied to the measurement of viscosity is described. Dimensional analysis was used to derive general relations between the variables involved and the simple calibration for the rolling ball viscometer in the streamline region of fluid flow. The coefficient of the calibration equation can be calculated from the dimensions of the instrument with the aid of an experimentally determined empirical factor. By using the equations given, the useful range of the rolling ball can be predicted without experimental calibration or an instrument can be designed for measurements over any desired range of viscosity. An empirical correlation is given that allows viscosity to be estimated from data taken on the viscometer in the turbulent region of fluid flow. The effect of temperature changes on the viscometer and its calibration are discussed. The advantages of the falling ball viscometer are: that the apparatus can be extremely simple, that a small sample is required, that visual observation in glass apparatus is possible, and that it possesses great flexibility with opportunity for changing one or more of the variables such as tube diameter, ball diameter, angle of inclination, ball density and rolling distance of the ball.

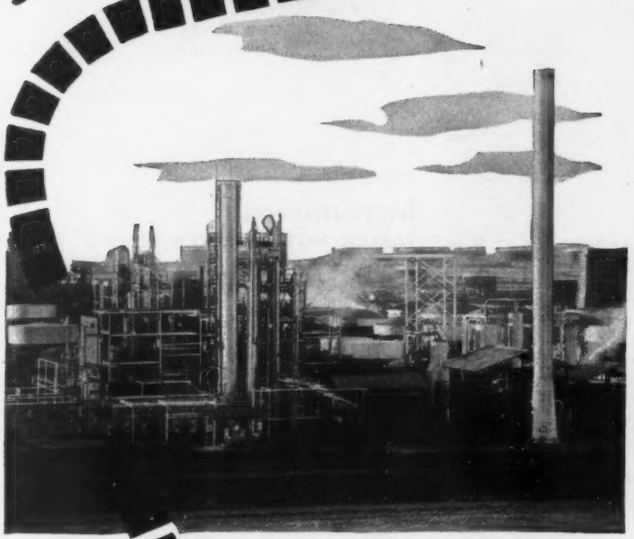
Gas Institute Adds Woman to its Staff

Miss Frances Estes is the first woman to become a member of the staff of the Institute of Gas Technology, Chicago. As a laboratory technician, she does her work along with 26 male members of the staff.

Miss Estes is a graduate of Kalamazoo College, 1940, where she majored in chemistry. Before going to the institute staff she was with Johnson & Johnson.

Hydrofluoric Alkylation makes important use of

Florite*



New refinery unit for Hydrofluoric Alkylation. Photograph courtesy of Continental Oil Company.

As a satisfactory desiccant and adsorbent for exacting technical processes like hydrofluoric alkylation, FLORITE is approved by leading industrial concerns. The modern plant here illustrated is typical of the extent, complexity, and very highly specialized character of installations devoted to such refining processes.

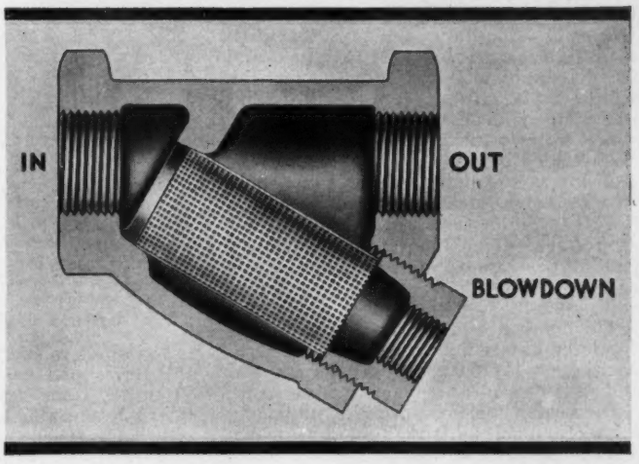
FLORITE is remarkable for its long-term effectiveness, which favors economical operation in the drying of propane, butane, air, nitrogen, carbon dioxide, refrigeration compounds, and other fluids. Write for data. Specific inquiries are welcomed by the manufacturers.

*Trade Mark Registered.

FLORIDIN COMPANY, INC.
ADSORBENTS

184 Liberty St. Warren, Pa.

The manufacturer of SUPER-SILVERTOP STEAM TRAPS



also makes ANDERSON SELF-CLEANING STRAINERS

ANDERSON improved strainers with their stainless steel elements remove scale, grit and sediment from the steam line.

This strainer cleans itself when a blowdown valve is used or when the pipe plug is removed. It's easy to install and inexpensive so that one can be used on every piece of equipment—pressure regulating valves and metering devices, liquid and gas lines, steam traps and air tools, spray heads and oil burners, solvent stills and temperature regulating valves. Write for "How To Choose A Steam Trap" which gives complete specifications.

THE V. D. ANDERSON CO.
1942 West 96th Street • Cleveland, Ohio

NEW EQUIPMENT FOR THE MODERN PLANT

Vertical Turbine Pump

LAYNE & BOWLER, INC.

Layne & Bowler, Inc., Memphis, Tennessee, recently has designed and developed a line of high capacity vertical turbine pump bowls. These bowls are intended primarily for pumping water from flowing streams or lakes for war plants, but may be used in large diameter wells for industrial or municipal water supplies.

The Memphis factory recently has fabricated five complete pumping units for a synthetic rubber plant. These units are equipped with the new two-stage 30-inch Type SKHC Bowls, designed to deliver 11,000 gallons per minute against a total dynamic head of 169-feet and are driven by 500-horsepower, vertical, hollow-shaft motors. They will be installed in a large diameter caisson and pump water from a flowing stream.

Another lot of 15 complete pumps, also for a synthetic rubber plant, will have newly developed 36-inch Type RKMC, single-stage bowls. The capacity range will be from 11,000 to 14,600 gallons per minute, and the pumps will be driven by 500-horsepower, vertical, hollow-shaft, synchronous motors.

This new line of high-capacity, large diameter bowls includes designs for capacities up to 16,000 gallons per minute, and all bowls are true turbine type. Noteworthy features are the unusually high efficiencies throughout a wide capacity range and the non-overloading type impellers used. These features make the new bowls especially desirable for pumping from rivers or streams where fluctuating water levels are encountered, with consequent variation in capacities and pumping heads.

Layne & Bowler Turbine Pump

Three-Liquid Pump

MILTON ROY PUMPS

Milton Roy Pumps, 1315 E. Mermaid Avenue, Philadelphia, announces a new step-valve pump. This pump delivers three liquids, one heavy viscous material and two very light materials, at various required rates of flow to accurately control the volume of each in a compounding operation.

Features of the pump include three Milton Roy step-valves, one with a single cover-plate. All valves have non-clogging, self-cleaning double-ball checks on both inlet and discharge sides. The units are standard type with plungers driven by a single motor, variable plunger stroke while operating, assembled on a special welded-steel base.

The pump is applicable for practically all processing chemicals, petroleum products intermediates, and other slurries as well as fibres and solids in suspension.

Instruments

TAYLOR INSTRUMENT COMPANIES

Taylor Instrument Companies, Rochester, New York, announce two new items of interest to the refining industry: The Booster Relay Air Valve, and the Automatic-Manual Unit for Fulscope Controllers.

The Booster Relay Air Valve has been designed for better process control through faster operation of large diaphragm valve motors or of valves located at unusually long distances from controlling instruments. It is an auxiliary device which provides accelerated valve action to eliminate the effect of lag in large diaphragm motors and/or in long air lines between controlling instruments and diaphragm motors.

It is claimed that under these difficult conditions, the relay air valve will inflate or deflate the largest Taylor valve motor (diaphragm of 144 square inches) from five to seven times faster than by controller alone. Installed in the air line adjacent to the diaphragm motor, it actuates the diaphragm valve by means of an independent air supply of 25 to 150 psi, which is applied or relieved through large ports. This action is in direct proportion to controller output. The ratio is 1 to 1. Process stability is increased by causing valve action to closely follow controlling instrument output changes.

On applications of processing where

Taylor Booster Relay Air Valve

When you want a good Unit . . . . .

Use the 'SHELLFIN'* standardized shell & finned tube heat exchanger!

*Pat. Applied For

You get the benefits of a premium quality heat exchanger built on a cost-saving, time-saving, production basis when you choose the SHELLFIN. For — expensive, time-consuming individual engineering is eliminated.

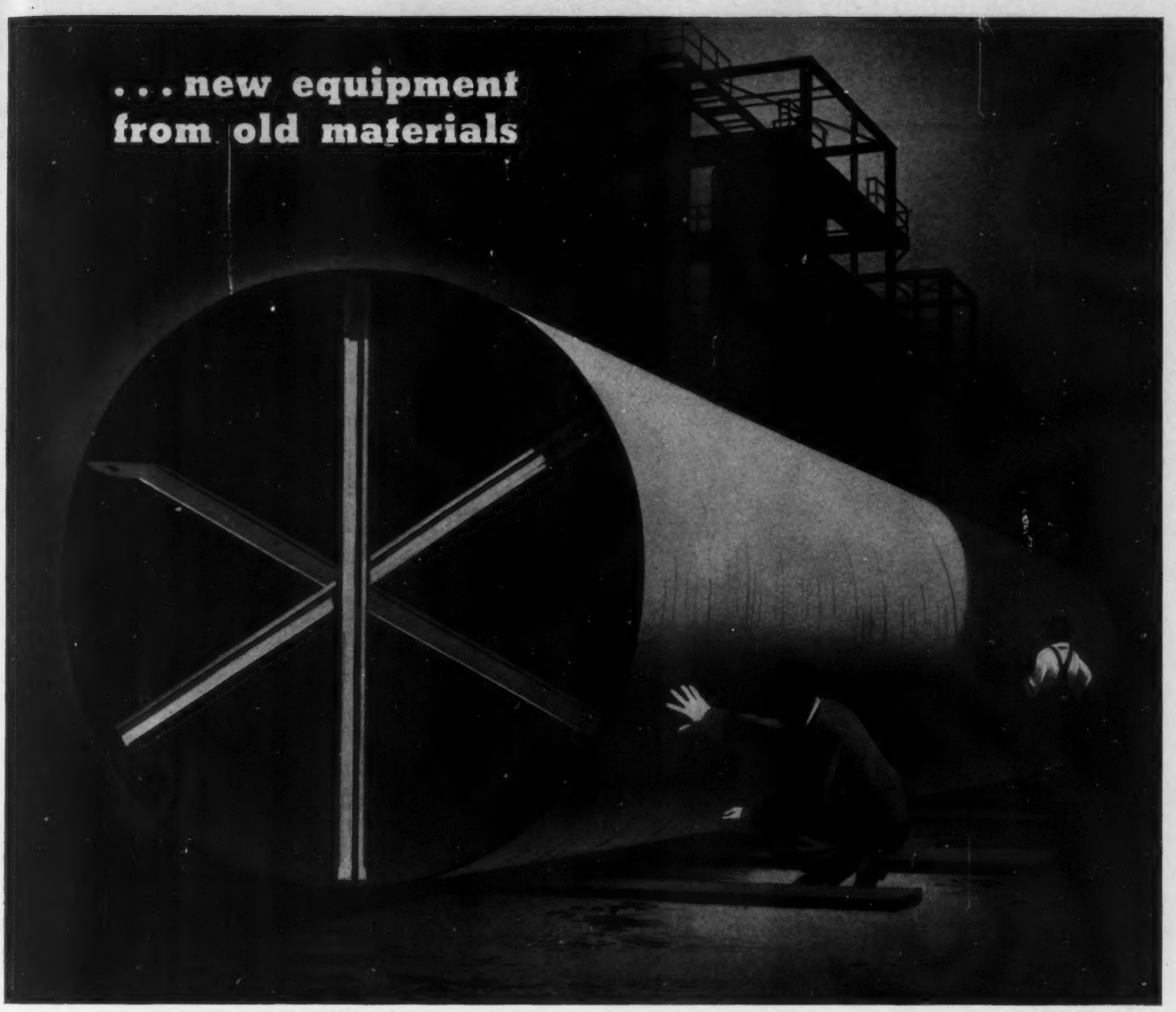
SHELLFIN units are varied only with minor changes in construction, such as baffle spacing and length combinations. Otherwise they conform to the standard design developed by Downingtown engineers . . . a design which meets fully the conditions common to a wide variety of uses for heat exchangers!

AN IDEAL UNIT FOR COOLING, HEATING, CONDENSING, EVAPORATING

Use SHELLFIN for many forms of heat exchange between two fluids in medium temperature ranges, where the heat transfer rate of one fluid is materially greater than that of the other. Use it for *cooling* oils, benzene, toluene and similar organic compounds, alcohols, chemical compounds generally . . . for cooling jacket water for diesel or gas engines, drain and condensate cooling . . . for air cooling in compression systems . . . for *heating* many of the above or similar fluids . . . for *condensing* organic vapors, hydrocarbon oil vapors, refrigerants . . . for *evaporating* organic liquids, light hydrocarbons and refrigerants. *It's an excellent performer in all of these services!*

DOWNINGTOWN IRON WORKS
DOWNINGTOWN, PA.
HEAT EXCHANGERS

NEW FOLDER answers your questions about SHELLFIN. Write on your letterhead for copy.



Information supplied by "Petroleum Refiner"

If the present emergency has done nothing else it has stimulated inventiveness and ingenuity. The story of building a 156-foot fractionating tower from old oil storage tanks is an example; it may also contain some helpful hints.

The tanks were dismantled by cutting each ring at the riveted lap, and after cleaning, the sheets were inspected for corrosion and pitting. When thickness fell below the specified minimum, the sheet was built up by welding and ground to restore the surface. Tensile strength was determined from coupons cut at random.

Before rolling each section, the edges were beveled for welding. Rolling was done in two passes, the first bringing the sheet within three feet of the desired diameter, and the second bringing the edges close enough for welding.

Rings thus formed were welded together to form the tower. Heat treating facilities were not available, so stress relieving of welded joints was done by cold working. This was accomplished by equipping an air hammer with a blunt bit, and hammering the plate thoroughly on both sides of the weld.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

MOLY

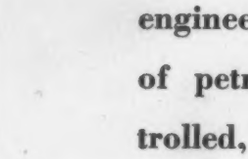
Climax Molybdenum Company
500 Fifth Avenue • New York City

"The life and soul of science is its practical application."
—Lord Kelvin

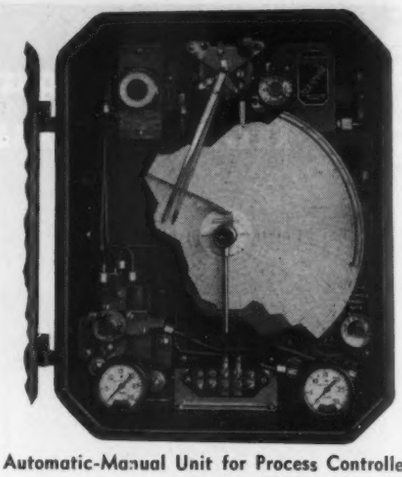
1821-1894
Herman Ludwig Ferdinand von Helmholtz, after achieving fame in physiological optics, devoted his researches to physics among which thermodynamics was notable.

Helmholtz developed the recognized theories of the equivalence of energy and heat which resulted in some of the primary laws of thermodynamics.

Engineering is applied science. Perhaps some of the most notable engineering achievements are in the field of petroleum refining. Here the controlled, economical application of heat demands a specialized engineering skill in the design and construction of heaters. A pioneer in this field, Alcorn for nineteen years has provided all types of heater installations to meet the exacting requirements for the processing of all types of petroleum products.



ALCORN
Combustion Company
SCHAFF BUILDING, PHILADELPHIA
Los Angeles • Houston • San Francisco



Automatic-Manual Unit for Process Controllers

it is more convenient to start up a continuous process on manual control and then switch to automatic control as soon as the process becomes stabilized, automatic-manual unit has been developed. This unit has several improvements over Previous Taylor models:

When the new unit is in a "manual" position, controlling air pressures are also applied to the idle mechanism of the Fulscope controller which is thus maintained in constant balance with the process. Because of this balance, control can be changed instantly from "manual" to "automatic" without causing process disturbances.

In addition to the three usual positions, "automatic," "manual" and "service," this unit contains a fourth step, "test." Set at "test," control is manual but the full 20 psi supply pressure is applied to the instrument mechanism to make possible its complete and accurate readjustment without disturbing the position of the controlled diaphragm valve.

The automatic-manual unit is designed to be installed entirely within the case of a Fulscope single-duty recorder controller. It can be supplied already installed in new instruments, or it may be added to equipment already in the field, without the need of either drilling or tapping the Fulscope instrument.

Sight Flow Indicator

FISCHER & PORTER COMPANY

Fischer & Porter Company, Hatboro, Pennsylvania, have perfected a new sight flow indicator called the Rota-Sight, designed for protection against low flow or excess flow.

The device shows when liquid is passing through the line and, in addition, has an indicating float which moves up and down the pyrex tube in direct proportion to the amount of flow. This float also responds to invisible gas flows in the same manner.

This response to flow is obtained by the use of a pyrex tube into which triangular flutes, similar to the V-ports of a valve disc, have been fashioned by a precision-bore tube-forming process. In this manner a variable area meter is obtained with a wide range over a short scale length. The device is said to be sufficiently sensitive to indicate the second that the fluid flow starts.

Inner sections of the tube between the flutes are arcs of a circle into which the flat fits with just enough clearance to allow it to move without binding. Thus the float is guided through its travel and can always be readily seen even though

Here's the STARTLING PROOF

of viscosity compensation in flow rate measurement with the STABL-VIS ROTAMETER!

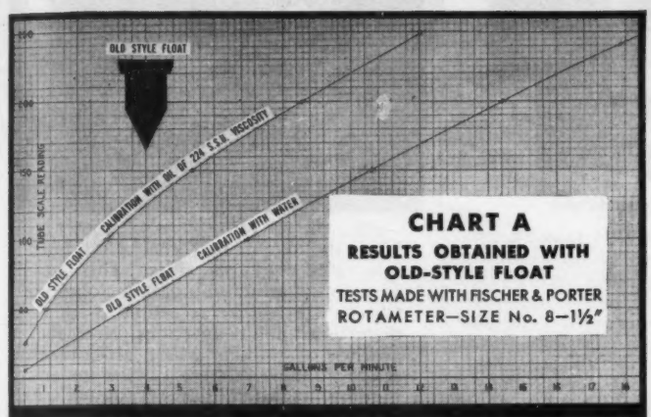


CHART A
RESULTS OBTAINED WITH OLD-STYLE FLOAT
TESTS MADE WITH FISCHER & PORTER ROTAMETER—SIZE No. 8—1½"

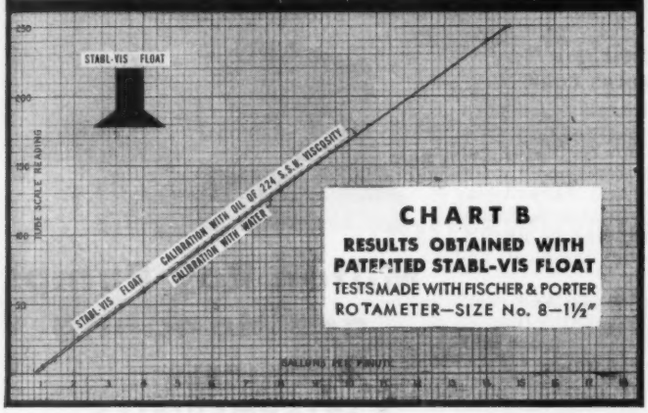


CHART B
RESULTS OBTAINED WITH PATENTED STABL-VIS FLOAT
TESTS MADE WITH FISCHER & PORTER ROTAMETER—SIZE No. 8—1½"

PRIOR to the development of the Stabl-Vis rotameter, accurate flow rate measurement of viscous fluids was impossible except with automatic temperature control or a whole series of painstaking calibrations covering every few points of change in viscosity. Charts "A" and "B" prove how the Stabl-Vis rotameter has removed these difficulties.

Chart "A" shows calibrations for water, and for oil with a viscosity of 224 S.S.U. using a size 1½" rotameter with an old style float. The average error introduced by the change to viscous oil from water is 33⅓%, based on the water flow.

Chart "B" gives calibration for water and the same oil of 224 S.S.U. with the Stabl-Vis rotameter. The curves are drawn apart slightly to show there are two curves. Actually, they practically duplicate one another. The change from water at 31 S.S.U. to oil at 224 S.S.U. has been made while maintaining a calibration accuracy of 99.5%.

For you in the Process Industries this proof of the metering accuracy of the Stabl-Vis rotameter has great significance. It means that flow rates of liquids such as sulphuric acid, caustic soda, oil, solutions of chemical salts, syrups, slurries, colloidal solutions, and hundreds of other fluids whose viscosities vary sharply with temperature may now be determined instantaneously with great accuracy. It is the final development that makes the rotameter completely superior to fixed orifice meters for flow rate measurement.

The Stabl-Vis feature can be built into all of our rotameters over size ¼". It can be included in meters manufactured for direct reading at the point of rotameter installation, or for remote reading at the main control panel. All recording and recording-controlling rotameters may also have this remarkable new development.

The theory and construction of the Stabl-Vis designs are described in our catalog section 80-A, a thorough technical treatise upon the rotameter. It is crammed full of useful and instructive information. We will gladly mail this really valuable booklet to you without any obligation — just let us know where to send your copy. Fischer & Porter Co., 195 County Line Rd., Hatboro, Pa.

F&P ROTAMETERS

FOR STANDARD HIGH HEAD SERVICE. Types T and XT Capacities: Up to 150 G P M or 200 lbs differential pressure.

FOR HIGH TEMPERATURES up to 850° F Types PT and PXT Cradle mounting, stuffing box, and ball bearings all water cooled. Capacities: Up to 150 G.P.M. or 175 lbs. differential pressure.

Quick Facts

ABOUT D-D TURBINE PUMPS

HIGH PRESSURES IN SINGLE STAGE — Regenerative principle of this pump enables its single, multivaned impeller, operating at normal speeds, to develop very high pressure in single stage.

LOW NPSH REQUIREMENT — Lower pressure drop (suction loss) is an outstanding turbine pump characteristic. This characteristic assures satisfactory operation under minimum head conditions.

ONE LOW-PRESSURE STUFFING BOX — Subjected to suction pressure *only* — never to discharge pressure. Minimizes chance for leakage. Ideal for volatile liquids.

SELF-PRIMING . . . HANDLES VAPOR WITH LIQUID — Pump keeps its prime after initial start. Gradual increase in pressure from inlet to discharge minimizes possibility of vapor-locking.

CRITICAL METALS MINIMIZED — Only a small casing, two sideplates and the impeller comprise the pump-end. Saves on critical metals. Lowers cost of corrosion-resisting construction.

ONLY 1 ROTATING PART . . . NO FRICTIONAL CONTACT — Single impeller rotates freely without wear from metal-to-metal contact.

PERFECT HYDRAULIC BALANCE — Liquid is delivered *equally* to *both* sides of impeller through twin inlet openings. Eliminates thrust on ball bearings.

LOWER COST STAND-BY PROTECTION — Wearing surfaces are all incorporated in side-plates and impeller. Extra set affords stand-by protection at nominal cost.

Free **TURBINE PUMP DATA BOOK**
144 pages of illustrations, performance curves, selection tables, installation and operating information on turbine pumps. *Write on your business letterhead for your FREE copy today!*

DAYTON-DOWD COMPANY
QUINCY, ILLINOIS
Offices in Principal Cities

TURBINE AND CENTRIFUGAL PUMPS

YOUR ANSWER for speeding wartime MAINTENANCE

Drum Cleaning Made Easier

Spending too much time on drum washing in your plant? Here's an effective way to simplify the job and save man-hours for other maintenance work. Wash drums in recommended solution of Oakite material designed for use in your particular washing equipment. Then rinse. That's all!

All oil, dirt and grease are removed THOROUGHLY and SPEEDILY. No film or other deposit remains to contaminate fresh oil. And for stripping before repainting, other SAFE Oakite materials are available that make drum washing and stripping a single, time-conserving operation . . . WITHOUT objectionable fumes or odors.

Write for FREE Data

We can help you speed other cleaning work as well . . . descaling cooling systems, salvaging dirty valves and fittings, cleaning heat exchangers, etc. Send for full, specific information.

OAKITE PRODUCTS, INC.
50B Thames Street, New York
Technical Service Representatives Located in All Principal Cities of the United States and Canada

OAKITE Specialized CLEANING

Buy Bonds for Victory

the fluid passing through the indicator may be opaque.

The indicator is applicable to any installation where an approximate idea of the amount of fluid-flow rate is an oper-

Rota-Sight Flow Indicator

ating help and necessity. It may be used for flows of cooling water, air agitation, gas blanketing, gas leakage, lubricating oils, filter feeds, filter backwash, overflows, circulating mediums or coagulating additives. Cast iron and bronze are standard metals used for the construction of the indicator, but it may be obtained in any corrosion-resistant metal required.

Glass Fiber Packing

OWENS-CORNING FIBERGLAS CORP.

Owens-Corning Fiberglas Corporation, New York, announces a new glass fiber packing material for rectifying columns. This material replaces tinned-copper bubble plates, and burned-clay Raschig rings, critical materials, and is said to be practical for use in distillation applications in the chemical and petroleum industries.

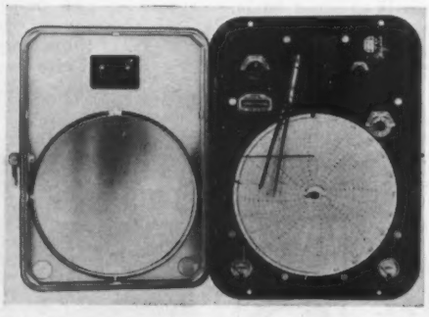
Operation of columns packed with glass fibers is identical with that of columns packed with tinned-copper bubble plates or the Raschig rings. Heated vapors rise from stills producing the normal run of 120-140-proof alcohol pass up through the column. Water and other liquids with a boiling point higher than 170 degrees condense on the glass fibers and flow back to be re-heated and re-vaporized by the rising vapors from the still until all alcohol is extracted from them.

Automatic Controller

THE BRISTOL COMPANY

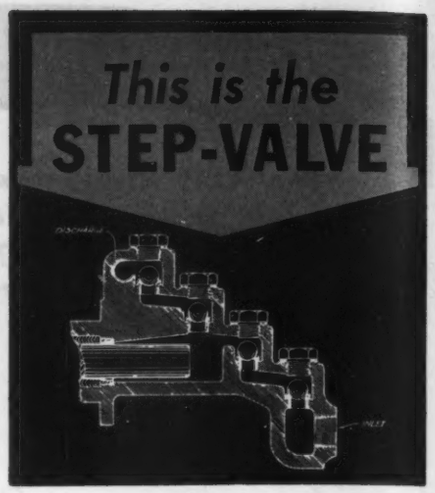
The Bristol Company, Waterbury, Connecticut, has developed a new air-operated automatic control instrument, the Convertible Free-Vane Controller, for automatically controlling temperature as high as 3600° F., flow, liquid level, pressure, draft humidity, pH value, and time program.

A number of refinements are included

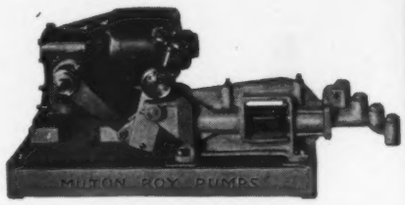


Bristol Automatic Controller

This is the STEP-VALVE



Note the double-ball checks on both inlet and discharge sides. This construction is self-cleaning, non-clogging. Checks are readily accessible, without disturbing pipe connections. Note also absence of pockets where air-bubbles might form . . . there can be no air-binding. Positive seating means no wire-drawing.



Milton Roy Pumps are Handling

- CHEMICALS
- INTERMEDIATES
- LIQUID LATEX
- LIGHT FRACTIONS
- IN PRECISELY CONTROLLED VOLUME

and refinery products of many kinds, including asphalts, acid sludge, high concentrations of solids in suspension, propane, butane and similar types of light hydrocarbons.

Milton Roy Pumps are plunger type, positive displacement units. They handle practically all liquid materials, in precisely controlled volumes, against pressures up to 20,000 lbs. per sq. in.

Step-Valves are built in corrosion-resistant and other metals for practically every chemical service, may be jacketed for temperature control. Pumps have accurate mechanisms for adjusting plunger stroke, from zero to maximum, while operating if desired. Many other features worth investigating.

Write for Bulletins and Catalogs.

Wire or 'phone if your needs are urgent, we may be able to help.

MILTON Roy PUMPS
1383 E. MERMAID AVE., CHESTNUT HILL, PHILA., PA.

INTERLOCKED IS ONE ROD PACKING THAT Can't Come Apart

TODAY virtually the entire production of J-M Packings and Gaskets is urgently needed for weapons of war, the factories that produce those weapons and the ships and planes that carry them to the fighting fronts. As a result, delivery on other than high-priority orders may be slower than in normal times. However, through increased capacity and a 24-hour-a-day, 7-day-a-week schedule, every step is being taken to assure the fastest delivery possible under the present emergency.
JOHNS-MANVILLE
JM
PRODUCTS

J-M INTERLOCKED—

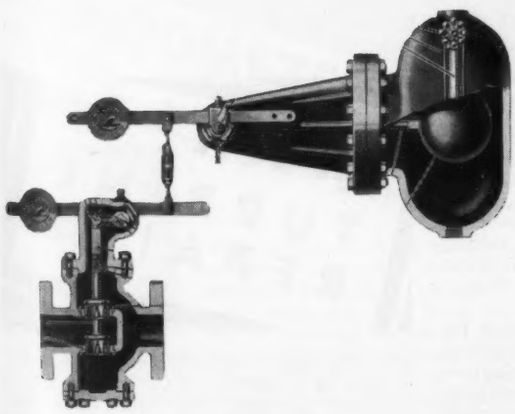
THE GREATEST SINGLE IMPROVEMENT EVER MADE IN BRAIDED PACKING

Once Interlocked is installed, you can be sure that repacking jobs will be few and far between. This unique braided material has no jackets to wear through or come apart . . . no plaits to loosen. It is braided square, and thus presents a better contacting area . . . provides a tight seal with minimum gland pressure.

For details, write for Catalog PK-12A. Johns-Manville, 22 East 40th Street, New York.

Johns-Manville PACKINGS & GASKETS

Call on K & M . . . *to keep your Control Equipment at peak efficiency!*



Our entire manufacturing output has gone to war . . . but 65 years of know-how is here to help you. If you have a pressure or fluid control problem—*any kind* of an installation, operating or maintenance problem—*call on K & M.* Our new VALVE PROBLEMS CLINIC is a clearing house of information established to keep your machinery going. There is no charge for this service. You needn't be using K & M equipment. But you have a job to do . . . and we want to *help* you do it, with specific, informative, resultful assistance.

UNITROL Self-contained Liquid Level Controller — for feed or drain regulation. Highly responsive — there are no packing glands, stuffing boxes or other restrictive elements to interfere with free movement. Exclusive design — for more efficient, accurate and trouble-free operation.

KM KIELEY MUELLER ESTABLISHED 1879

Kieley & Mueller

ENGINEERED PRESSURE & FLUID CONTROL SPECIALTIES

NORTH BERGEN, NEW JERSEY

Representatives in all Principal Cities

THERE IS WHY IT IS GOOD BUSINESS TO SEE THAT YOU GET

BATES-GRATES

FOR OPEN STEEL FLOORING

That scraper edge on the Bates open steel flooring cross bar is cleaner and safer. You grasp the idea from even a quick glance at the picture. Yet it doesn't cost you a cent more.

You get those extra advantages because the Bates patented process builds a fillet from displaced metal—in addition to the clean scraper tread of the "Hex" cross bar, giving you smoother, cleaner, larger welds *and stronger flooring.*

The whole process is explained—and many fine installations pictured—in the 8½ x 11 catalog, "FILLET-WELD BATES GRATES." Write for a copy.

WALTER BATES COMPANY, INC.
JOLIET, ILLINOIS
OPEN STEEL FLOORING • STAIR TREADS

in the instrument and it is designed so that the user can convert from one type of control system to another.

The controller is offered in Monoset (on and off), Ampliset (throttling), Preset, Reset, and Magniset. Adjustments for fitting the controller to the requirements of the process are located on the dial board above the chart.

Tube Cleaner

THOMAS C. WILSON, INCORPORATED

Thomas C. Wilson, Incorporated, 21-11 44th Avenue, Long Island City, New York, announces a new type tube cleaner, designed to clean small diameter tubes from ⅜ to 1¼ inches, used in condensers, heat exchangers and similar apparatus. The cleaner operates at high speed and uses a cutter-bit, enabling the cleaning of a large number of tubes in a short time. Entire bundles of tubes can often be cleaned with the device without removal from the shell.

The company has also designed an attachment to be used with the cleaner which gives the cutter-bit the combined movement of a rotary cleaner and a percussion hammer. This attachment facilitates breaking up very hard deposits in tubes. It is operated by air or steam used as the scavenging agent in the tube cleaner. Its use is also recommended for cleaning either partly or totally plugged tubes in which an especially hard deposit is encountered.

Wire Reinforced V-Belt

THE B. F. GOODRICH COMPANY

The B. F. Goodrich Company announces production of wire reinforced V-belts. Two types are being built, a cable-cord construction and a grommet construction which incorporates a wire cord placed in the center of a cotton or rayon grommet.

Designed for the most rigorous service, advantages of the wire-reinforced V-belt type are said to be greater horsepower capacity, increased tensile strength and low stretch.

The company emphasizes that only after full engineering details of the equipment on which the belt may be used and operating conditions are studied, will it be able to decide whether a wire belt will be practical.

Line Starter

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

For machine tools, textile machinery, pumps, fans and similar machines, a new size 2 class 11-200 linestarter requiring less than half the mounting space of former units without sacrifice of wiring space is announced by Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

This compact linestarter designed for group mountings, built-in applications or remote mountings has a new clapper-type armature with knife-edge bearings. It utilizes double-break silver-to-silver contacts, thus eliminating shunts and reducing maintenance. Overload relays are reset either by hand or automatically. On applications requiring sequence or auxiliary interlocking, provision is made on the size 2 linestarter for a total of four normally open or normally closed electrical interlocks.

All parts of the new unit are accessible from the front and all control circuit terminals and interlock terminals are clearly marked for easy installation and repair.

Asbestos Cement

PHILIP CAREY MANUFACTURING COMPANY

Philip Carey Manufacturing Company, Lackland, Cincinnati, is now providing a new asbestos-cement conduit, intended primarily for use in cable installations. An outstanding feature of the product is the Flexcaulk coupling, made especially for the conduit.

The coupling consists of a tubular housing of tough, rigid, blow-resisting asbestos-cement, to which is bonded a liner of time-resisting mineralized asphalt compound, formed into a barrier-type, tapered liner. Because of its special construction, "Flexcaulk" coupling adds a new flexibility without sacrificing any of the desirable characteristics of a conventional type coupling of unusual strength. It permits a flexible, self-aligning, water-tight joint of exceptional quality, when properly assembled with a special, joint-sealing compound.

Because the coupling is employed with non-taper type conduit, the field assembly of short lengths of complete duct runs, or the fabrication of radius sweeps for clearing fixed obstructions, becomes a simple, inexpensive job. Once installed, the duct bank remains water-tight, even under ground-settling action.

The asbestos cement conduit itself, in addition to recognized advantages of this type, over war-restricted metal conduit, is said to be exceptionally tough, hard and dense; stronger and more blow-resistant; meeting perfectly the demand for an earth enveloped duct system that is permanent, trouble-free, and proportionately inexpensive in its initial installation. The conduit is made in two thicknesses, for installation with or without concrete encasement.

Waterproof Adhesives

PAISLEY PRODUCTS

Paisley Products, 1770 Canalport Avenue, Chicago, has developed a new series of water-resistant and waterproof glues, pastes and cements, with various working qualities to suit the newer types of export packing material now in use. Included in the series are vegetable base adhesives, synthetic resin emulsions, casein-resin formulations, thermo-setting and thermo-plastic cements.

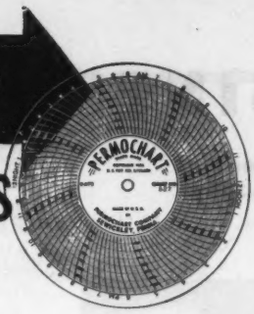
QUICK TURBINE REPAIRS

If you need dependable Turbine repairs **in a hurry,** call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

25 Years Successful Experience

GULF ENGINEERING CO., INC.
"Service, Not Promises"
307 M. & M. BUILDING, HOUSTON, TEXAS
916 S. PETERS STREET, NEW ORLEANS, LA.

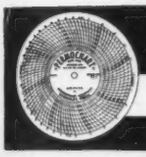
Investigate PERMOCHARTS



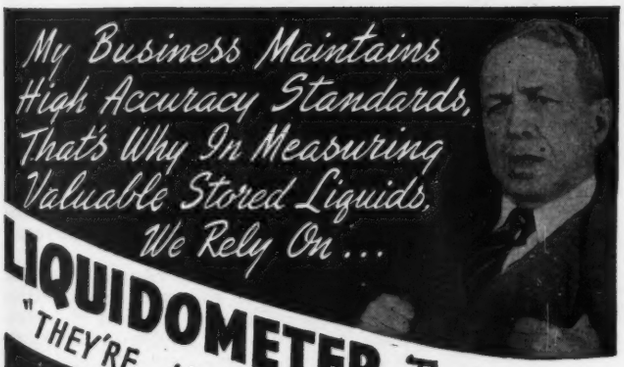
Reusable, recording, plastic instrument charts that wipe clean with a damp cloth.

- Avoid delays incident to paper shortage and printing by supplementing your supply of paper charts with reusable PERMOCHARTS. Made of Vinylite plastic and available in white and three I-EZ shades—green, ivory, and blue.
- PERMOCHARTS are being accepted as standard circular recording instrument charts by leading Petroleum, Chemical, Food, Public Utility, Iron and Steel industries and other fields. PERMOCHARTS are guaranteed for two years continuous use.
- We also supply high-quality recording ink in three colors —purple, green, and red.
- PERMOCHARTS *cost less in the long run*—actually about 1/5 as much as paper charts.

PRICE RANGES (F. O. B. Sewickley, Pennsylvania)
Up to 8"—$1.50 each; up to 10"—$2.00 each;
up to 12"—$2.50 each · Ink—2 oz. 70c; 8 oz. $2.00
Minimum Order—3 Charts
Write for Literature and Quantity Discounts

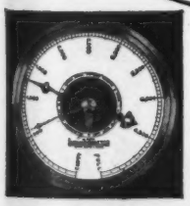


PERMOCHART Company
544 CHESTNUT ROAD
SEWICKLEY, PENNSYLVANIA



LIQUIDOMETER Tank Gauges

"THEY'RE ALWAYS DEPENDABLE"



100% automatic—these tank gauges insure accurate, trouble-free readings whenever required. No pumps, valves, or auxiliary units required to read them. Models available so that readings can be taken remotely from or directly at the tank. Remote reading types utilize balanced hydraulic transmission system which completely compensates for temperature variations on communicating tubing. Accuracy unaffected by specific gravity of tank liquid.

Approved for gauging hazardous liquids by Underwriters' Laboratories and other similar groups. Models available to automatically control pumps, motors, signals or other devices for maintaining minimum or maximum liquid levels.

Write for complete details.

THE LIQUIDOMETER CORP.
39-14 SKILLMAN AVE., LONG ISLAND CITY, N.Y.

For Continuing Achievement

A STAR FOR WESTON

—*evidence that the vital instrument situation rests in good hands!*

A star now adorns the ARMY-NAVY "E" pennant awarded to WESTON just 6 months ago . . . the first such pennant awarded in this highly specialized instrument field.

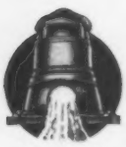
It's a star that has *real meaning.* Because, from the very beginning of our defense period, the responsibility for producing the vast quantities of instruments vital to the success of our country's efforts, has rested largely on the instrument leader.

This star signifies that the responsibility *rests in good hands.* "The men and women of the WESTON Electrical Instrument Corporation," writes the Chairman of the Navy Board for Production Awards, "have achieved a signal honor by continuing their splendid production in such volume as to justify this award . . . indicating their solid determination and ability to support our fighting forces with equipment necessary for victory."

But a great instrument task still remains . . . before victory is ours. So WESTON workers continue reaching for new goals . . . with the same determination, the same painstaking devotion to the quality ideal, responsible for WESTON'S *continuing leadership* in the instrument field. Weston Electrical Instrument Corporation, Newark, New Jersey.

WESTON *Instruments*

New Worlds To Conquer



In the present war emergency, the service provided by Layne has been of inestimable value. Thousands of highly efficient well water systems for military, naval, munition and war material needs have been constructed in unbelievably short periods of time.

But over tomorrow's horizon—in the post-war period—there are new worlds to conquer. Municipal and industrial well water development projects now being held in abeyance to save war materials and manpower, will be rushed to completion.

When peace returns, the Layne organization will be ready to provide an incomparable service. There will be pumps of improved design to further increase high efficiency, tougher materials to add more years of long life, unmatched manufacturing facilities to speed production and hundreds of thoroughly trained men for field and service duty.

It will be Layne who has the demonstrated skill, the wealth of experience and the most complete facilities for building the world's finest Well Water Systems and Pumps. For literature, write, Layne & Bowler, Inc., General Offices, Memphis, Tenn.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Bowler New England Corp., Boston, Mass. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City, Mo. ★ Layne-Western Co. of Minnesota, Minneapolis, Minn. ★ International Water Supply Ltd., London, Ontario, Canada.

LAYNE

WELL WATER SYSTEMS

DEEP WELL PUMPS

Builders of Well Water Systems for Every Municipal and Industrial Need

☆ BUSINESS NOTES ☆

Cox Elected President of National Tube Company

Charles R. Cox has recently been elected president of National Tube Company and of Tubular Alloy Steel Corporation, Pittsburgh. He has been associated with National Tube Company since 1934. At that time he was employed at the Ellwood Works, where he soon became general superintendent. In 1936, he was appointed vice president in charge of operations of National Tube Company, with headquarters in Pittsburgh.

C. R. Cox

C. J. Bickler Appointed By Globe Steel Tubes

C. J. Bickler has been appointed assistant to the vice president in charge of sales, according to an announcement from Globe Steel Tubes Company, Milwaukee. His headquarters will be Milwaukee.

Supply Association Has Annual Meeting

Completion of arrangements for entertaining the Natural Gasoline Association of America and election of officials made up most of the business of the annual meeting of the Natural Gasoline Supply Men's Association, April 4 in Dallas. The question of limitation of membership was considered with decision not to place limitation as to the number of members.

Officials elected are Charles D. Peterson, Fisher Governor Company, Tulsa, president; A. M. Buxton, Cooper-Bessemer Corporation, Tulsa; and J. A. Knebel, Joseph A. Coy Company, Tulsa, vice presidents; V. C. Canter, Frick-Reid Supply Corporation, Tulsa, treasurer.

The following were elected as directors for two-year periods: A. M. Buxton, V. C. Canter, R. E. Walker, American Rolling Mill Company; Fred J. Wetzel, Ingersoll-Rand Company; Charles D. Peterson, and George W. Probst, Clark Brothers Company, ex-officio as retiring presidents.

They will serve with the following who held over from the previous year: L. J. Griffey, Hanlon-Waters, Inc.; J. A. Knebel, Warner Lewis, Warner Lewis Company; C. S. Simons, Midwest Piping & Supply Company; Paul C. Wallack, Walco Engineering & Construction Company.

Johns Hopkins Course In Control Instruments

Johns Hopkins University has established a special course to train technicians in the use of industrial instruments and controls.

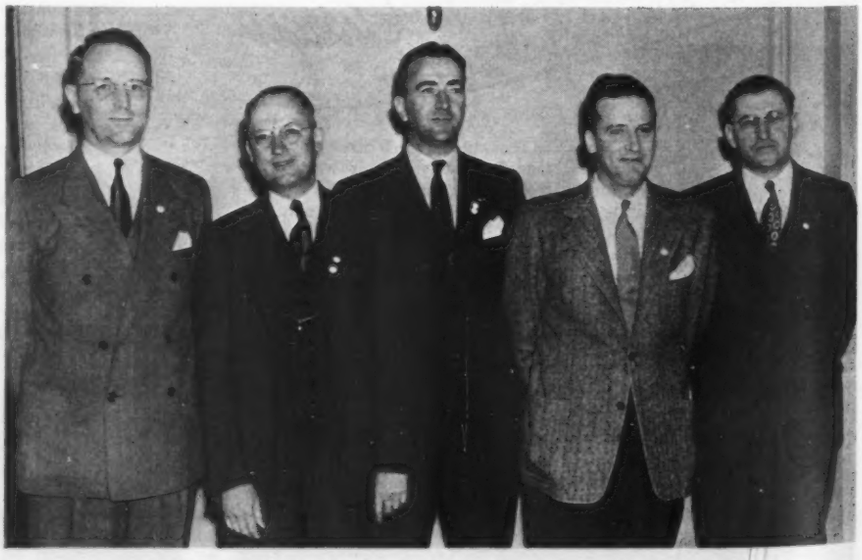
The Brown Instrument division of Minneapolis-Honeywell Regulator Company is cooperating in the educational program by assigning as guest lecturers, members of its Philadelphia technical staff. They will explain the working of such instruments as the recently developed electronic potentiometer, the Radiamatic pyrometer and air-operated process controls.

Sixty picked men from war plants in the Baltimore area are attending the classes, which are under the direction of Dr. R. B. Anderson and which include both lecturers and laboratory instruction in the principles of temperature measurement and use and maintenance of control instruments.

Armstrong Cork Makes Promotions

Armstrong Cork Company has announced the following promotions in its personnel: Keith Powlison, vice president and controller; M. J. Warnock, treasurer, succeeding Powlison, and Cameron Hawley, director of advertising to succeed Warnock.

Powlison joined the company in 1922 as a member of the sales organization of the floor division. He left the company to return to academic work, re-



Left to right: A. M. Buxton, V. C. Canter, George W. Probst, J. A. Knebel and Charles D. Peterson

WANTED!

MECHANICAL OR PROCESS ENGINEER

Want mechanical or process engineer who is experienced in **equipment or calculations** used in the CHEMICAL OR MANUFACTURED GAS INDUSTRIES — such as washers, gas holders, pumps, instruments, furnaces; or heat balance, absorption, water gas generation, gas handling, etc.

Good salary, permanent position, excellent future. Give full details of experience, education, personal data. Address:

Personnel Director

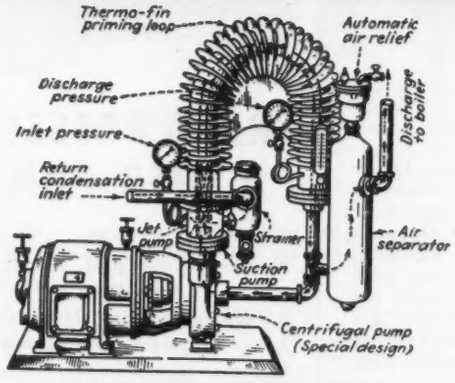
THE GIRDLER CORPORATION

Gas Processes Division

224 E. BROADWAY LOUISVILLE, KY.

C-B *High-Pressure* CONDENSATE RETURN SYSTEM

for REBOILER CONDENSATE DRAINAGE



EXCLUSIVE JET PUMP DESIGN

OPERATES IN A CLOSED CIRCUIT

MAINTAINS PRESSURE DIFFERENTIAL across process equipment, with discharge of condensate against higher pressures without FLASH LOSS or necessity for high static suction head — flash tank — float control or auxiliary pump

INCREASES EFFICIENCY — assures constant evacuation of condensate and entrained air from equipment — maintains maximum, uniform heat transfer rates

LOWERS STEAM COSTS — by direct return of hot condensate to waste heat boiler — surge tank or pressure return line to boiler plant.

AUTOMATIC IN OPERATION

SUBMIT PROBLEMS without obligation — Ask for Publ #3025

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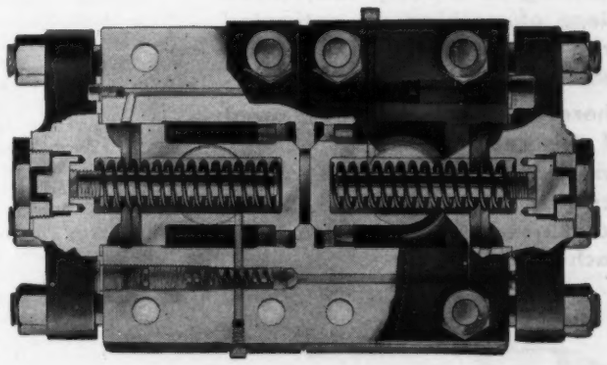
● A problem presented — studied — solved! It's the firm policy of BAYARD to follow through every assignment in the designing, engineering and creating of machinery for a specific purpose with ingenuity and skill born of long years of experience.

●

SPECIAL VALVES HEAT EXCHANGERS
THERMO WELLS PRESSURE FITTINGS



DUPLEX RELIEF VALVE
for Closed Hydraulic Systems

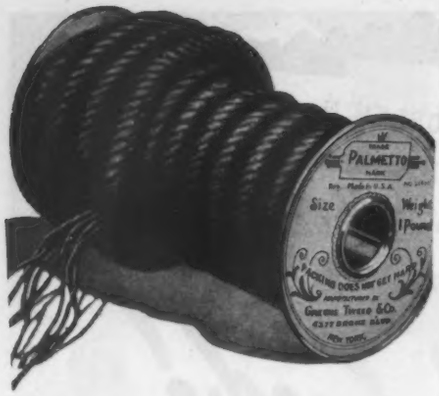
Relieves excessive pressure from the high side to the low side, independent of which side of the system happens to have excessive pressure.

The coveted Navy "E" Pennant — awarded to Bayard for excellence in fulfilling Naval contracts.

BAYARD

M. L. BAYARD & CO., Inc.

ENGINEERS • MACHINISTS • PHILADELPHIA



ONE SPOOL

provides a stock of packing for many sizes of valves

. . . because EACH INDIVIDUAL STRAND of PALMETTO Twisted Packing is a fully lubricated piece of packing . . . saturated with special PALMETTO graphite lubricant.

Therefore, when you buy a spool of this self-lubricating packing, just separate the strands for different sizes of valves . . . you don't need a separate stock for each valve size.

WRITE FOR LITERATURE

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For rods and shafts; layer over layer construction insures uniformly even bearing surfaces.

TWISTED
For valve stems, each strand a perfect piece of lubricated packing.

GREENE, TWEED & COMPANY
Bronx Blvd. at 238th St., New York, N. Y.

PALMETTO
for steam, hot water, air. PALCO *for water.*
PELRO *for oils.* CUTNO *for alkalis.*
SUPERCUTNO *(blue asbestos) for acids.*
KLERO *for foods.*
SELF-LUBRICATING
PACKINGS

ceiving the degree of Doctor of Philosophy in Economics at Johns Hopkins University in 1928. After a period of association with the Security-First National Bank of Los Angeles, he returned to the Armstrong Cork Company as assistant treasurer in 1932. In 1938 he was elected treasurer.

A graduate of the University of Oregon, Warnock came with the Armstrong company as a salesman in 1926. He served as manager of the company's office in Seattle before coming to Lancaster as assistant manager of the floor di-

MERIT AWARDS

Awards of merit have been made by the Government to the following firms:

Chicago Bridge & Iron Company, Pacific Coast Yard, Army-Navy E for outstanding performance in wartime construction.

Tide Water Associated Oil Company, Avon Refinery, Minute Man T Flag symbolizing the participation of more than 90 percent of the refinery's employes in the company's payroll allotment plan for the purchase of War Savings Bonds.

Kerotest Manufacturing Company, Pittsburgh, Pennsylvania, Gold Star to Maritime Commission's M, in recognition of continued outstanding achievement in wartime production. The original M was awarded to Kerotest last August.

Elliott Company, Jeanette, Pennsylvania, Army-Navy E for excellence in production of wartime products.

Sterling Engine Company, Buffalo, New York, Army-Navy E for excellence in war production.

Scovill Manufacturing Company, Army-Navy E for the second time in six months, for meritorious services on the production front.

De Laval Steam Turbine Company, Trenton, New Jersey, Army-Navy E for excellence in industrial production, second award and carried the honor of a white Star to the E burgee.

Socony Paint Products, Long Island City, New York, Maritime M, Victory Fleet Flag, and Maritime Merit Burgee, for production record in the war effort.

Foster Wheeler Corporation, Dansville, New York, Fourth Army-Navy E with star for excellence in production.

American Cast Iron Pipe Company, Birmingham, Alabama, Army-Navy E, Minute Man Flag, for exceptional performance in supplying war material for America's fighting forces, and for participation of more than 90 percent of the employes in the payroll deduction plan for purchase of War Bonds.

Mine Safety Appliance Company, Pittsburgh, Pennsylvania, Maritime M Pennant and Victory Fleet Flag, for outstanding production for the war effort.

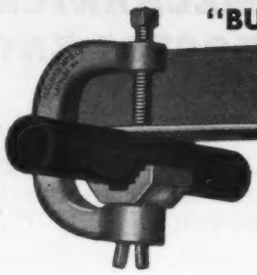
Foote Brothers Gear & Machine Corporation, 5225 South Western Avenue, Chicago, Army-Navy E for excellence in production.

Midwest Piping & Supply Company, St. Louis, Missouri, Army-Navy E for excellence in War Production.

Clark Brothers Company, Olean, New York, Army-Navy E for a fine record in production of war equipment.

Leeds & Northrup Company, Philadelphia, Pennsylvania, Army-Navy E for high achievement in the production of war equipment.

Latrobe PRODUCTS
★ FLOOR BOXES ★ WIRING SPECIALTIES ★



"BULL DOG" PIPE OR CONDUIT HANGERS

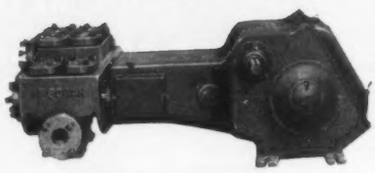
Holds pipe with bull dog tenacity. Made of high quality malleable iron. Adaptable for such wide range of use that it makes itself a necessity in refineries, mills and factories. Saddle turns for pipe to run parallel or at angles to beam.

Insulator Support with Hanger attached to Conduit

Furnished complete with stove bolts and machine screws for attaching Hangers to Insulator Supports.

Jobbers Inquiries Invited

FULLMAN MANUFACTURING CO.
LATROBE . . . PENNSYLVANIA



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2½—4 x 6 Stroke.
Pressure—1000 p.s.i. working.
2000 p.s.i. hydrostatic.
Double suction and shaft extension.
Roller bearings—herringbone gears.
Interchangeable liners.
Trim to suit pumping conditions.

Also manufacturers of these type pumps:

SIMPLEX and DUPLEX
STEAM and
POWER DRIVEN
HORIZONTAL and
VERTICAL
FORGED STEEL, CAST STEEL
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ALLOYS
VALVE PLATE, SIDE POT
MISCELLANEOUS DESIGNS

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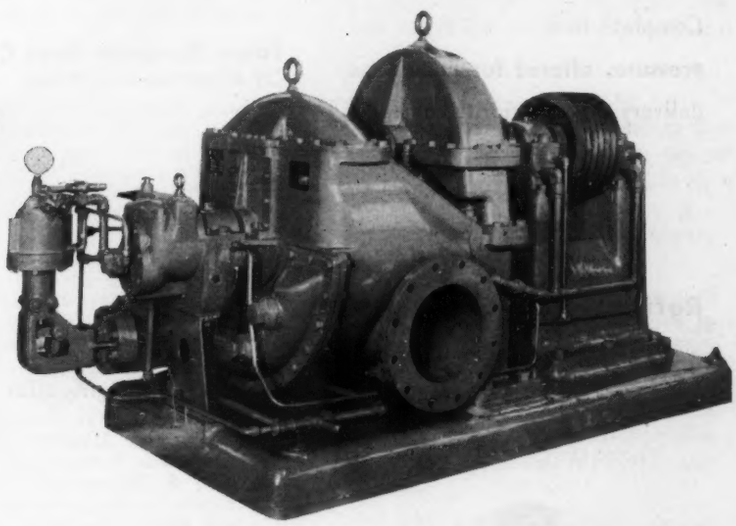
complete line of industrial equipment

MURRAY

TYPE UG

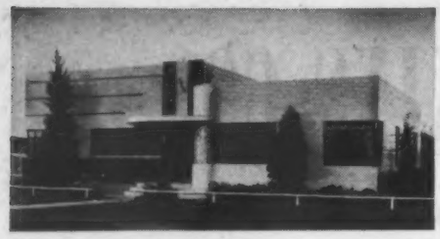
Integral Geared Turbine



Type "UG" Integral Geared Turbine consists of the Type "U" Mechanical Drive Turbine with integral single or double helical reduction gear. Turbine is supported by the gear at the turbine shaft centerline thereby avoiding misalignment due to the heating of the turbine casing.

View shows unit equipped with variable speed direct acting oil pump governor, and extended low speed shaft with sheave for V-belt drive.

MURRAY IRON WORKS COMPANY, Burlington, Iowa



Valves
and
Fittings

RECONDITIONED
GUARANTEED

☆

Complete lines — All types and pressures offered for immediate delivery. No priority needed.

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Refinery Equipment —
Pumps — Pressure
Vessels — Tanks

S.G.S.

SONKEN-GALAMBA
SUPPLY COMPANY
UNION AVE. AT 21st STREET
TULSA, OKLA.

vision in 1930. He was named director of advertising and promotion in 1941.

Hawley, who joined the company in 1927, has served in a number of sales, advertising and sales promotion capacities, including that of director of Armstrong's bureau of retail merchandising. Since 1941 he has been assistant director of advertising and promotion.

Greene, Tweed & Company Names Two Representatives

J. J. McIntosh and B. F. Coombs have been appointed sales representatives for Greene, Tweed & Company. McIntosh will cover Alabama, Florida, Georgia, Mississippi, North Carolina, and Tennessee east of the Tennessee River. His headquarters will be 1106 McLynn Avenue, Atlanta, Georgia. Coombs will represent the company in Eastern Texas and Western Louisiana, with headquarters at Route 12, Box 495, Houston, Texas.

General Electric Names Electronic Specialists

General Electric Company, Schenectady, New York, has designated 18 industrial electronics specialists, who will assist industry in the application of electronics to industrial problems.

The men and their locations are: I. C. Diefenderfer and D. C. Hierath, New York; J. F. Getz, Philadelphia; A. J. Moore, Boston; W. B. Frackelton, Chicago; L. E. Donahue, Los Angeles; J. A. Setter, Denver; I. F. Conrad, St. Louis; A. D. Boardman, San Francisco; L. B. Parsell, Detroit; L. R. Elder, Portland, Oregon; Frank C. Neal, Jr., Dallas; R. H. Jackson, Atlanta; K. H. Keller, Cleveland; R. C. Norris, Cincinnati; A. M. Dawson, Pittsburgh; B. Cogswell, Buffalo; L. F. Stone, Newark.

Talon Company Buys Control Of Electroweld Steel

Talon, Incorporated, Meadville, Pennsylvania, recently purchased controlling interest in the stock of Electroweld Steel Corporation, Oil City, Pennsylvania. The latter company manufactures pressure and mechanical steel tubing, a product which meets the demands for boiler, condenser, heat exchanger, and other mechanical applications. Capacity of the plant is approximately 6000 tons per month.

Al Campbell Now With Kieley & Mueller

Al Campbell has become associated with Kieley & Mueller, as sales manager. He was formerly with Manning, Maxwell & Moore, and has had long experience in the power-plant industry. He will direct the sales of engineered pressure and fluid-control specialties.

Wanted — Refinery superintendent with engineering knowledge, capable of operating combination topping and vis breaking unit. Address Box 506, c/o Petroleum Refiner, Houston, Texas.

FOR SALE: Complete 150-ton capacity absorption refrigerating machinery. Steam driven air compressor 650 C.F.M. Steam driven A.C. generator 75 K.W. 220-3-60. Two Vogt water tube boilers 250 H.P., each, 125 lbs. ice cans, cranes, steam pumps, Taylor recording thermometers, anemometers, psychrometers.

CAPITAL ICE REFRIGERATING CO.
356 W. North St., Indianapolis, Indiana.

BUSINESS OPPORTUNITY

Are dismantling complete oil refinery to obtain certain vital materials. The surplus equipment could be easily converted to the processing of asphalt and greases. Location in the heart of several Army Camps. If you know asphalt operation and are in position to finance do it now. We will assist any responsible party with terms to suit requirements. 90% of the equipment is installed and ready plus a good warehouse, office, etc. Address P. O. Box 1421 or Phone 2-1740, Alexandria, La.

REFINERY MAINTENANCE ENGINEER

Man thoroughly familiar with machine shop practice, as well as all types of refinery mechanical equipment, including pumps, compressors, turbines, motors, boiler house equipment, etc. A graduate engineer who has served a machinist's or mechanic's apprenticeship is preferred. Position is of supervisory nature in engineering or maintenance department of middle size refinery in the Middle West. In reply, state draft status and salary required, as well as a complete outline of education and experience. Box 555, c/o Petroleum Refiner, Houston, Texas.

WANTED
Mechanical Engineer

Well established Midwest Pump Manufacturer offers position of Chief Engineer to man experienced in the Design of Reciprocating and Centrifugal Pumps. This position is permanent and offers an experienced man the opportunity to become part of the management in a well financed Company, which is now on war work. Please answer giving complete experience, draft status, personal history, etc. All replies will be held confidential. Address Box 222, c/o Petroleum Refiner, Houston, Texas.

WANTED
CHEMICAL ENGINEERS
CHEMISTS
OPERATORS

For new aviation alkylation and isomerization plant in Middle West.

Give full particulars.

Address: Box 334, c/o Petroleum Refiner, Houston, Texas.

WANTED

Engineer, mechanical or chemical with experience in industrial instruments and process work in oil refineries. Work will include the development of specifications and the application of instruments in the oil and chemical industry. Considerable traveling involved and successful applicant will be given wide freedom for original thought and action.

Box 444,
PETROLEUM REFINER,
Houston, Texas